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33rd INTERNATIONAL MEETING OF SEDIMENTOLOGY

16ème CONGRÈS FRANÇAIS DE SÉDIMENTOLOGIE

ABSTRACT BOOK

IMS 2017

33rd

INTERNATIONAL MEETING

OF

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16ème

CONGRÈS FRANÇAIS

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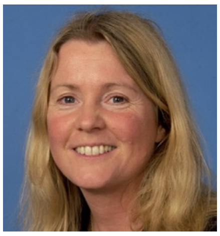
SÉDIMENTOLOGIE

INVITED

Speakers & Keynotes

INVITED SPEAKERS

WHAT HAS CONTROLLED CARBONATE MINERALOGY THROUGH GEOLOGICAL TIME?



Rachel WOOD

Professor of Carbonate Geoscience
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Rachel Wood has particularly interests in the evolution of carbonate systems through time, in response to biological evolution, mass extinction, and changing sea water chemistry. Her current research focuses on the rise of biomineralisation during the Ediacaran/Cambrian transition and the modelling of carbonate diagenesis.

CHARACTERIZATION OF SHELF MARGIN SEDIMENTARY PRISMS

Ronald J. STEEL

Davis Centennial Chair and Professor in clastic sedimentology
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The main focus of my research over the last 15 years or so, has been to gain an understanding of the time scales, clastic sediment delivery mechanisms, sediment budget partitioning and growth styles of shelves and deepwater shelf margins. I am also engaged in understanding relationships between sea-level change and tides, and in particular in developing models of tidal dunes and bars on deltas, estuaries and shelves.

THE PERMO-TRIASSIC MASS EXTINCTION AND ITS AFTERMATH: TO HELL AND BACK

Paul WIGNALL

Professor of Palaeoenvironments
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Paul Wignall has a long standing interest in mass extinctions, the environmental changes associated with them and the large igneous provinces with which they coincide. He has particularly focused on the Permo-Triassic crisis and has visited many boundary sections around the world. Allied to these research interests, Wignall also studies anoxic events and the proxies used for their recognition, and the role of high temperatures in ancient crises.

INVITED KEYNOTES

WHAT HAS CONTROLLED CARBONATE MINERALOGY THROUGH GEOLOGICAL TIME?

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A substantial body of empirical and experimental data supports the hypothesis that inorganic carbonate mineralogy has changed through the Phanerozoic and probably before. It has been proposed that conditions have oscillated between those that have facilitated the preferential formation of aragonite + high Mg calcite (HMC) mineralogies, termed ‘aragonite’ seas, and those which favored low Mg calcite (LMC) mineralogies, termed ‘calcite’ seas. This oscillation is thought to be caused by a secular variation in Mg/Ca ratio of seawater, changes in carbon dioxide partial pressure (pCO_2), and also changes in dissolved SO_4, which decreases the Mg/Ca ratio at which calcite is destabilized and aragonite becomes the dominant $CaCO_3$ polymorph.

In this talk I wish to explore the relationship between extrinsically-driven changes in seawater chemistry and biological response, and also the nature of potential feedbacks. Many animal (metazoan) skeletons are composed of calcium carbonate [$CaCO_3$], forming as aragonite, LMC or HMC. By contrast, dolomite [$CaMg(CO_3)_2$] has a highly ordered crystal lattice with slow kinetic growth rates, does not readily form in modern oceans despite supersaturation, and has never been documented as a biomineral. This is of note because early metazoan skeletal clades commonly co-opted carbonate minerals in concert with ambient ocean chemistry.

In addition, mimetic preservation by dolomite (i.e., retention of original crystallographic orientation) of originally aragonite and/or HMC grains as well as dolomite cements provides evidence that early marine dolomite precipitation dominated Cryogenian to early Ediacaran oceans (ca. 740 to ca. 630 Million years ago). This is inferred to be due to widespread low-oxygen oceans or stratified oceans and high-Mg/Ca seawater. The presence of high iron (ferroan) concentrations in early dolomite cements and ferroan dolomite concretions in shales further indicates that these oceans were anoxic and ferruginous. These so-called “aragonite-dolomite seas” are thought to have been largely replaced by “aragonite seas” during the Ediacaran.

Ratios in Mg/Ca are presumed to have been driven by enhanced rates of mid-ocean ridge expansion which promotes the preferential removal of Mg from seawater via hydrothermal reactions. Plate tectonic activity as a driver for Mg/Ca ratios does not satisfy, however, data that show that seawater composition has changed during the past 40 Million years even though seafloor spreading rates have been nearly constant. Mineral proxies of inferred major changes in Mg/Ca ratios may also record Mg removal from seawater by basinalto global-scale processes, such as dolomitization of large, expansive platforms during periods of high sea level.

A quantitative compilation of carbonate skeletal mineralogy through the Phanerozoic shows a progressive replacement of low-Mg calcite (LMC) by aragonite. This general trend overrides the subsidiary trend of Greenhouse intervals favoring biogenic ‘calcite’ seas, and Icehouse intervals facilitating ‘aragonite’ seas. The replacement of low-Mg calcite by aragonite was, however, achieved episodically at mass extinction intervals. In particular, the end-Permian extinction both preferentially removed species bearing ‘unfavorable’ LMC, and allowed the selective radiation of biota with ‘favorable’ aragonite. This demonstrates the importance of ‘incumbency’ in the evolution of skeletal mineralogy.

INVITED KEYNOTES

CHARACTERIZATION OF SHELF-MARGIN SEDIMENTARY PRISMS

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Shelf-margin sedimentary prisms result from long-term feeding of river-sediment discharge into deepwater basins, with the gradual construction of a shelf to bridge the terrestrial and deepwater systems. They represent the major part of source-to-sink sediment volumes. Key segments within any clinothem of prism growth are (1) the sandy alluvial to shelf platforms (topset) bounded at seaward end by zone of maximum coastal regression, (2) the channelized but muddy deepwater slope and (3) the basin-floor that is also commonly sandy near the base of slope. These three clinoform segments also constitute the classic stratigraphic sequence. Successive clinothems accrete onto each other by a mechanism whereby the sediment delivering delta systems repeatedly transit (regressive and transgressive shifts of 100s of km) the growing shelf platform, usually at time scales of 100-300 Ky depending on climate setting. In a second, quite different type of system from gradually accreting and aggrading shelf margins, sediment can be transported from land, directly through long-lived, shelf-dissecting canyons, to fans very distant from the deepwater slope.

We examine a range of shelf-margin cases from the Orinoco, Spitsbergen, Pearl River, Washakie. Neuquén and Gulf of Mexico and note irregularities in the grain-size partitioning through the S2S system due to channelized sediment bypassing in the coastal plain and deepwater slope, and to sediment storage near the shelfslope break. We also note recent discussion of clinothem characterization, and deviation from the classic sequence-stratigraphic geometry.

INVITED KEYNOTES

THE PERMO-TRIASSIC MASS EXTINCTION AND ITS AFTERMATH: TO HELL AND BACK

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The nature and cause of the mass extinction at the end of the Permian has been the subject of intense research for 30 years. Its aftermath is equally fascinating because the return of “normal” marine conditions (both the sedimentology and benthic life) appears to have been delayed until at least the Middle Triassic over 5 million years late making it the longest post-extinction recovery interval of any crisis. The contemporaneous eruption of the Siberian Traps flood basalts and the associated gas releases are usually implicated in the extinction mechanisms. However, the relative importance of the variously proposed kill mechanisms (anoxia, acidification, sea-level change, temperature change, ozone depletion) are hotly debated. Field evidence reveals that the main extinction phase was immediately predated by a sea-level fall, most clearly manifest in shallow, carbonate platforms of Tethys. It seems unlikely that such a type-2 sequence boundary could be a cause of mass extinction though – they are ten-a-penny in the Phanerozoic. The subsequent rapid transgression and the spread of anoxic waters provides a better extinction mechanism although transgressive black shales were also a common phenomenon in the pre-Cenozoic world. However, the Permo-Triassic anoxic event was exceptional. Uniquely, it was globally distributed in shelf seas and also manifest in the open ocean making it the most severe, oceanic anoxic event of the past 500 myrs. Furthermore, the spread of anoxia went hand-in-hand with a phase of rapid warming that culminated in some of the warmest sea-surface temperatures ever recorded.

Recovery from the harsh conditions of the Permo-Triassic extinction was prolonged, and alpha diversity in marine habitats did not return to Permian levels until the Middle Triassic over 5 million years after the crisis. The intervening time saw the frequent occurrence in clastic shelf settings of textured organic surfaces (TOS) typical of those more normally encountered in the pre-metazoan sedimentary strata of the Precambrian. The carbonate ramps of Tethys also saw the proliferation of stromatolites and thrombolites, another apparently Precambrian-like facies reappearance. There has been a prolonged debate, as to the significance of these anachronistic Lower Triassic sediments. Does it reflect an uninhabited world, emptied by the mass extinction that produced a Precambrian-like faunal desert? Or, does it reflect the prolongation of stressful conditions producing widespread uninhabitable conditions? New evidence from Arctic clastic shelf outcrops suggests the latter. TOS development was restricted to a “Goldilocks zone” that was shallow enough to be within the photic zone, allowing microbial mat growth, but deep enough to be bathed in dysoxic bottom waters, thereby inhibiting metazoan grazing. Only as the world cooled and the oceans became better ventilated did the marine benthic realm fully recovery and TOS and microbial carbonates once again disappeared from open marine settings.

ABSTRACTS

Résumés

FACIES ANALYSIS AND PALEOENVIRONMENTAL INTERPRETATION OF APTIAN CARBONATES PLATFORM (DJEBEL DEBBAGH) NORTH EAST ALGERIA

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Mount Debbagh represents the most important massive of eastern Constantinois neritic (Northeast Algeria), it is characterized by its potential mining resources with two types of mineralization. It consists of autochthonous formations of Triassic to Miocene which are hosted in carbonate formations of Cretaceous. The reconstruction of the paleo-environments of deposition of this neritic platform was based on a detailed petrographic study of the samples from a geological section located west of the Debbagh massive on limestone formations of the Aptian. Petrographic interpretation yielded microfacies belonging to different paleo-environments, classified from the most distal to the most proximal in a model of deposition.

CONTRIBUTION OF CONTINENTAL AND MARINE TRACE FOSSILS IN IDENTIFYING SUBENVIRONMENTS AND DISCONTINUITY SURFACES: A CASE STUDY FROM THE UPPER EOCENE DUR AT TALAH SEQUENCE, SIRT BASIN, LIBYA

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Dur At Talah outcrop is a 150 m thick succession of Upper Eocene age. It is composed of fine-grained, siliciclastic strata. This succession exhibits an overall upwards grain size coarsening coincides with a clear increase in the embedded petrified woods. Apart from the conspicuous ichnological content, these characteristics refer to a continuously regressive sequence. The trace fossils along and across this sequence are remarkably variable in their abundance and diversity. Amongst the recognized ichnospecies bear a clear contrast in their environmental origin. Recognized marine species are *Diplocraterion*, *Teichichnus*, *Ophiomorpha*, and *Thalassinoides*. They are comparatively more frequent in the lower half of the sequence. Continental traces are produced by termites, crayfishes, and possibly lungfishes. These are found only locally in the lower part but dominate as we move upward the sequence. Close examination of the trace fossil assemblages provides a vital tool for identifying subtle depositional environments. This article focuses on the most diagnostic continental traces fossil species, namely the termites and the crayfish burrows. Their occurrences will be described here and their implications for recognizing sedimentary environments are discussed. These traces in combination with their sedimentological context provide an excellent indicator of fluvial-shallow marine interplay. The article also emphasizes the role of trace fossils in defining different depositional discontinuities. It highlights evidence of sea level fluctuations within what appears to be an uninterrupted regressive sequence.

SEDIMENTOLOGICAL CONTEXT OF EARLY JURASSIC DINOSAUR TRACKSITES (ELLIOT FORMATION, KAROO SUPERGROUP) IN THE ROMA VALLEY, LESOTHO

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Dinosaur tracksites within the Roma Valley of Lesotho found at different stratigraphic positions in the Lower Jurassic Elliot Formation were studied, with the aid of high resolution sedimentological assessments of the host rocks, to better understand the palaeoenvironmental and ichnite preservational conditions. The geochronology of the tracksites, using the U-Pb LA-ICPMS method on detrital zircons separated from the host rock, is currently underway to refine their temporal relationship. The ichnogenus present at all three sites are tridactyl tracks and trackways of the *Grallator-Eubrontes* spectrum. Additionally, the two sites (Lephoto and Motobo) preserve ichnites that belong to the ichnogenus *Trisauropodiscus* and *Kayentapus*, respectively. Sedimentologically all the track-bearing palaeosurfaces are preserved atop of tabular sheets of sandstone that are fine-grained, horizontally laminated, low-angle cross-laminated or massive, and are interbedded with mudstones that are pedogenically altered and contain in situ carbonate nodules, calcretizied root traces, invertebrate burrows, etc. The palaeosurfaces also preserve current ripple marks and desiccation cracks that vary in size from 5 to 50 cm. The UEF has been interpreted as a fluvio-lacustrine depositional system that experienced repeated periods of high energy, flash flooding and drying in the Early Jurassic. Under the semi-arid climatic conditions, pedogenic alteration of the floodplain sediments led, amongst others, to the bioturbation and precipitation of carbonate nodules in the palaeosols.

While the large-scale sedimentology of the three Roma Valley tracksites is similar, localized sedimentary features associated with the tracks vary within and amongst the tracksites. Footprint morphology is a function of dynamic trackmaker-substrate interaction; thus, the preserved tracks provide insights into the substrate conditions at the time of track formation. This is most simply illustrated by deep, undefined tracks with expulsion rims being interpreted to have formed in a saturated medium, whereas defined tracks with distinct morphological detail such as claw marks and digital pads being interpreted to have formed in a firmer medium. Some tracks show evidence of acting as microenvironments indicated by the preservation of pitted textures due to algal matting and invertebrate traces within the foot impressions. This suggests that the epirelief tracks formed on the sediment surface in small pools where micro-organisms and invertebrates could temporarily flourish, and ultimately assist in the footprint preservation.

DETRITAL CLAY MINERAL DISTRIBUTION THROUGHOUT A MODERN TURBIDITE SYSTEM

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Porosity and permeability of a host rock are the two important parameters controlling the quality of hydrocarbon reservoirs. These pore-scale attributes are typically controlled by depositional and diagenetic processes which commonly act together to determine the final properties of the reservoir. Although there are a significant number of individual studies concerning pore-scale reservoir quality controls of particular fields and/or formations, there are only a few overarching investigations that attempt to predict reservoir quality through linking depositional processes to early diagenetic pathways.

This is the first study to investigate the detrital clay distribution of an active turbidite system and attempt to predict possible early diagenetic pathways across the system. The study area (Bute Inlet) is an 80 km long fjord located in British Columbia, Canada, whose depth ranges between 20 and 660 m. The depositional system is dominated by a 45 km long and up to 90 m deep submarine channel that is shaped by quasimonthly turbidity currents. Repeat multibeam mapping, series of acoustic Doppler profiling moorings and bed sediment cores were obtained across the system. As such the Bute submarine channel system is the first where the flow properties of turbidity currents have been measured from their initiation at a delta clinoform to their ultimate dissipation across a terminal lobe.

The resultant deposits were sampled (undisturbed) by a series of piston (18) and box cores (21), whilst grab samples (14) were also collected to characterise general trends in surface sediments. The combination of flow measurement and extensive sampling gives us the unique opportunity to link flow dynamics to clay distribution in an active turbidite system for the first time. Here we present preliminary results of detrital clay distribution (both amount and clay types) throughout the system including along the thalweg and over the terraces of the main submarine channel. This is followed by a discussion of the possible implications of detrital clay distribution on the early diagenesis and evolution of pore-scale attributes of the deposits.

FACIES ARCHITECTURE, PALEOENVIRONMENTS AND SEQUENCE DEVELOPMENTS IN THE NEOPROTEROZOIC CARBONATES OF THE SCIC FORMATION (REPUBLIC OF THE CONGO)

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The Neoproterozoic Schisto-Calcaire Group (630 to ca. 580 Ma) was deposited on an extensive carbonate platform in the margin of the Congo Craton in the Niari-Nyanga and Comba subbasins (Gabon and Republic of the Congo). It consists of three carbonate-dominated subgroups (SCI to SCIII, 1300 m-thick) recording relative sea-level changes. The SCIc Formation at the upper part of the SCI Subgroup, shows a carbonate succession of meter-scale shallowing-upward cycles, composed of a sequence standard of 7 microfacies (MF) recording the evolution of a marine ramp from distal carbonate muds and giant stromatolitic bioherms (MF1-MF2), extensive ooid shoals (MF3) to proximal settings submitted to evaporation near a sabkha (MF7). Two types of fourth-to fifth-order parasequences are recognized, mainly on the basis of physical bounding surfaces; (i) subtidal cycles, bounded by marine flooding surfaces across which subfacies deepen; and (ii) peritidal cycles bounded by subaerial exposure surfaces. These cycles are the result of the interplay of relative sea-level changes due to eustatic variations related to periodic extensional tectonic events affecting the whole basin. They are enclosed into a third-order sequence related to the deposition of the SCI Subgroup during the final stage of a Highstand Systems Tract (HST) developed above the maximum flooding surface linked to the deglaciation of the Marinoan Snowball Earth event. The most typical sedimentologic feature of the SCIc Formation is the deposition of giant stromatolitic bioherms (stacked on up to 20 m) topped by ooid shoals (up to 75 meters thick) in the last part an aggrading phase (first part of the HST). These shoals formed a carbonate sandy barrier and initiated a prograding phase (second part of the HST) that ended in evaporitic and karstic conditions at the top of the SCIc Formation. This succession of 3rd order can be followed on more than 100 km in the Republic of Congo and several hundred km from South of Gabon to the Bas-Congo in the Democratic Republic of the Congo. The understanding of the internal architecture and evolution of the carbonate SCIc succession is an excellent example to understand oil and cement potentials in the Precambrian sedimentary systems at least at a regional scale.

PARADOXICAL DOLOMITE $^{87}SR/^{86}SR$ INCREASE WITH DEPTH – SEEPAGE REFLUX INTO DENSE GROUNDWATER

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The Trigonodus Dolomit is an important dolomite body of the Middle Triassic Upper Muschelkalk Formation, that covers an area of over 100 000 km^2 of the southern Central European Basin (CEB). The formation represents the sediments of a homoclinal carbonate ramp, situated in an extensive epeiric sea. Borehole data from Switzerland and France indicate that dolomitization, as a whole of the formation, is greatest at Middle Triassic paleoshorelines and wanes towards the centre of the southern CEB. This pattern along with the presence of primary anhydrite structures, and downwards directed textural changes suggests that dolomitization occurred due to seepage-reflux processes. Our petrographic, stable (C–O) and strontium isotopic analyses however, indicate that dolomitization occurred due to a unique geological phenomenon.

Prior to matrix dolomitization the formation underwent diagenesis in the seawater diagenetic environment (e.g. micritization, bladed cements), a mixing-zone environment (e.g. leaching, inversion, silicification) and ultimately in the meteoric diagenetic realm (e.g. calcite spar, reducing conditions, inclusion-free syntaxial cements). Oxygen isotope compositions ($\delta^{18}O$ VPDB) of the matrix low-magnesium calcites (LMC) vary slightly between6.03 ‰ and4.60 ‰, while LMC spars span from15.53 ‰ to4.42 ‰; average =9.36 ‰ VPDB. Calcite spar shows no evidence of recrystallization and predates dolomitization. Matrix dolomite oxygen isotope ratios span from6.56 ‰ to1.05 ‰, while dolomite strontium isotopic ratios ($^{87}Sr/^{86}Sr$) vary from 0.7081 to 0.7117, considerably higher than the Triassic marine $^{87}Sr/^{86}Sr$ ratio (0.70775). In each borehole dolomite $\delta^{18}O$ decreases and dolomite $^{87}Sr/^{86}Sr$ paradoxically increases with depth.

At the conclusion of the deposition of the Upper Muschelkalk, a sea-level fall resulted in the development of a coastal sabkha across much of Switzerland. Radiogenic and low $\delta^{18}O$ groundwaters infiltrated basinward from the Vindelician High paleoshoreline and precipitated LMC spar. Groundwater density and salinity increased over time to values greater than seawater due to evaporation. Therefore, during the subsequent sea-level rise the density contrast would have caused the encroaching seawater to float on the groundwater rather than displace it. The seawater lens became increasingly concentrated by evaporation and eventually refluxed into the groundwater. Dolomites formed at the top of the refluxing brine acquired seawater $^{87}Sr/^{86}Sr$ and high $\delta^{18}O$ compositions, while those at the base of the unit received more influence from the radiogenic and low $\delta^{18}O$ groundwater.

This combined petrographical and isotopic study suggests that later dolomite recrystallization is not required to explain the unique isotopic trends of the Trigonodus Dolomit. Ongoing study will focus on the geographic extent of groundwater infiltration in Switzerland and Germany.

THE DIACHRONISM OF THE CONIACIAN-SANTONIAN BOUNDARY: EXAMPLES FROM GSSP OF OLAZAGUTIA (SPAIN) AND TEN MILE CREEK-ARBOR PARK (USA)

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The mechanisms and palaeoenvironmental conditions leading to and through OAE3 are poorly known, particularly with regard to the marine phosphorus cycle and changes therein, and to the climate conditions in general. This study focuses on bulk sediment and clay mineralogy, phosphorus and carbon isotope geochemistry, high-resolution biostratigraphy, and changes in climate and primary productivity. Two sections from different palaeogeographic areas at different palaeodepths were studied. The 2 investigated sections were proposed as candidates for the base Santonian global boundary stratotype section and point (GSSP): Olazagutia (NW Spain) and Ten Mile Creek-Arbor Park (Texas, USA). The first one was recently ratified, and the base of Santonian was defined by the first occurrence of the inoceramid *Cladoceramus undulatoplicatus*. However, in the Olazagutia section, *C. undulatoplicatus* appears to occur well above the Coniacian-Santonian boundary as our nannofossil biostratigraphy suggests, and its first occurrence appears to have been environmentally controlled. In Texas, several bentonite layers have been recognized close to the proposed Coniacian-Santonian boundary, but only one provided sufficient well-preserved zircon minerals to allow accurate age dating of the Santonian. Based on a weathering index and mineralogy, similar climate changes are observed in all sections. The climate shifted synchronously from humid to relative drier conditions near the Coniacian-Santonian boundary, followed by a return to more humid conditions during the Santonian. Fluctuations in total phosphorus contents appear mainly to have been driven by changes in detrital input and consequently by climate in Spain and Texas.

RESPONSE OF TERRESTRIAL AND MARINE ENVIRONMENTS TO THE PALEOCENE-EOCENE THERMAL MAXIMUM (PETM), INSIGHTS FROM A BASIN-CONTINENT TRANSECT, NE AND CENTRAL PYRENEES, SPAIN

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Geochemical and mineralogical proxies of terrestrial and marine clay-rich sediments are an excellent tool to understand paleoenvironmental and climatic changes that occurred during the Paleocene-Eocene Thermal Maximum (PETM). Two sections, Zumaia and Esplugafreda, respectively located in the Basque Basin and South Central Pyrenees preserve a remarkably continuous record of the PETM events, which allows high-resolution correlations between continental and marine settings. The Esplugafreda section shows an excellent terrestrial record of the early Eocene warm events. High-resolution $\delta^{13}C$ and $\delta^{18}O$ analyses of two types of calcareous paleosoil nodules reveal two distinct negative excursions: a Pre-Onset Excursion (POE) and the Paleocene Eocene Thermal Maximum (PETM). The POE is located above an unconformity between red soil and calcarenitic fluvial to lacustrine sediments and corresponds to a sea-level rise and a rapid temperature increase (8°C). A second gradual warming from 6 to 8°C is observed in the upper part of the section and appears to be linked to the PETM. The Paleocene Eocene boundary is located four meters below the Claret conglomerate, which was previously thought to represent an extreme climatic event in the Pyrenees linked with the PETM. The Claret conglomerate was therefore deposited between these two climatic events and about 10m above the top of the POE and is therefore not directly related to the PETM-onset. A prominent increase in kaolinite content during the POE implies intensified runoff and/or weathering of adjacent soils. In the marine section of Zumaia, the PETM interval is marked by an abrupt change from turbidites to clay-rich sediments with dominant kaolinite. The presence of several peaks of mercury coincident with both POE and PETM intervals supports the role of volcanism (North Atlantic Igneous Province) to initiate the concomitant warming and sea-level rise characterizing the POE and PETM.

CURRENT HYDROSEDIMENTARY DYNAMIC OF THE DELTA MEDIUM IN THE OUEME ESTUARY IN BENIN

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The Inter year fluctuations of last three decades have been accompanied by a remarkable degradation of vegetation cover and recurrent floods in the Ouémé estuary. In this work, it is to analyse liquid and solid flow as well as conditions of sedimentary deposition remobilization during flooding. In September 2016, water characteristics have been measured by multiparameter and turbidimeter, the liquid flows with the IRD / Benin acoustic Doppler current profiler (aDcp). Sediments in suspension and these bottoms have been sampled for granulometric analysis. The water sampling has been retaken in March 2017 and the suspension matters (MES) of all waters have been analysed by molecular absorption spectrophotometer.

It is important to mention that the liquid flow of September 2016 flooding has been 616.984 m^3/s in Bonou and 571.61 m^3/s in Adjohoun. The suspension matters, the turbidity and the shear stress are higher in september and more important in Adjohoun than Bonou. The flows above mentioned have been sufficient to remobilize sediments with a median d50 lower to 0.125 mm in Bonou or 0.125 mm in Adjohoun. This remobilization manifest by an increasing of sedimentary flow from 46.292 kg/s in Bonou to 55.5719 kg/s in Adjohoun.

INCISION OF CHANNELS STIMULATED BY UNCONSOLIDATE GRAVELS SUPPLY AS STREAM SEDIMENTS IN ARID VALLEY OF CHILE

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The topographic evolution of orogens depends on the ability of valley insision. Current models of channel incision indicate that this ability is controlled by the rate of rock uplift, soil erodibility, channel geometry, properties and availability of sediments and climatic variables. In the Atacama Desert, where the climate is one the driest on the Earth, the unconsolidated neogene gravels are preserved in hillslopes and their deposits are incised by the current valleys. In this work, we studied the maturity of the channels of three main tributary catchments of the El Tránsito hydrological basin, from Numerical Models of Elevation and geological data to quantify differences in the incision. The tributaries have been subjected to similar climatic regimes and tectonic settings. Although there are these similarities, channels exhibit different degrees of incision and different concavity and steepness indexes. Channels that cross through thick deposits of miocene gravels are more incised, present higher retreat celerities and have lower steepness indexes, in relation to channels where the crystalline substrate is uncovered. Unconsolidated gravels are easier to erode and furthermore, as they are incorporated in the bed load, they provide the abrasive material, which led to a further incision downstream. This association is relevant in quantitative geomorphology studies as variation of valley incision is commonly used to infer climatic and tectonic changes in the Central Andes, suggesting the need for further studies to determine the role of unconsolidated sediment supply on river profiles evolution.

MARGALA HILL LIMESTONE A YPRESIAN CARBONATE RAMP DEPOSIT ON THE SUBDUCTING INDIAN PLATE MARGIN IN KASHMIR BASIN, NW LESSER HIMALAYAS, AZAD KASHMIR

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Sedimentation in Kashmir Basin resumed after a hiatus of about 505 my by depositing a transressive regressive Paleogene sequence on the subducting margin of Indian Plate in Neotethyan realm. In this sequence, on composite subaerial unconformity, Hangu Formation (Danian age) overlies well bedded dolomitized/silicified stromatolitic Abbottabad Formation (Cambrian in age) indicating a lowstand system tract (LST) followed by transgressive system tract (TST) Thanetian deposits represented by Lockhart Formation (carbonate) and Patala Formation (siliciclastic). Paleocene/Eocene boundary is marked by a maximum flooding surface present at the base of Margala Hill Limestone. Margala Hill Limestone, Chorgali and Kuldana formations of Ypresian to Lutetian age represent deposition in highstand system tract (HST). The Paleogene sequence was terminated by Middle Eocene subaerial unconformity due to suturing of India and Asia. The Himalayas started to rise with the deposition of molasses represented by Rawalpindi and Siwalik groups.

The present paper deals with the microfacies, paleogeography and depositional settings of Margala Hill Limestone, Ypresian in age, through biostratigraphic approach for which suitable stratigraphic sections were measured and thin sections were studied. Margala Hill Limestone is comprised dominantly of light grey to dark grey nodular limestone with sporadic intercalations of grey marl and shale. Thickness of limestone beds increase toward the top of the formation. The nodules vary in size from 4 to 30 cm in diameter and grey fossiliferous argillaceous limestone surrounds them. Margala Hill Limestone contains larger benthic foraminifera that include *Nummulites atacicus* (LEYMERIE), *N. mamillatus* (FICHTEL and MOLL), *Assilina subspinosa* DAVIES, *A. spinosa* DAVIES and PINFOLD, *A. granulosa* (d' ARCHIAC), *A. laminosa* GILL, *Lockhartia conditi* (NUTTALL), *L. tipperi* (DAVIES) and *Ranikothalia sindensis* (DAVIES). In addition to this, *Alveolina* sp., miliolids, oyesters, brachiopods, ostracods, pelecypods, corals, Dasycladaceaen algea and planktonic foraminifera were identified. In these deposits appearance of *N. atacicus* (LEYMERIE) indicates Paleocene/Eocene boundary at the top of Khaki shales of Patala Formation. Four Families of larger benthic foraminifera (LBF) identified are Nummulitidae, Rotaliidae, Alveolinidae and Miliolidae. Genera included in Nummulitidae Family are *Nummulites*, *Assilina*, *Operculina* and *Ranikothalia*. Rotaliidae Family is comprised dominantly of *Lockhartia* and only genera present in Alveolinidae Family is *Alveolina*. Family Miliolidae is comprised only of *Quinqueloculina*.

In present studies, three microfacies (MF) have been identified on the basis of preponderance of genera of foraminifera. Paleoecological information pertaining to identified fauna and its integration with lithological and sedimentological data has been utilized to decipher depositional settings of Margala Hill Limestone. The identified microfacies include Rotalidae MF, Nummulitidae MF and bioclastic MF. Rotalidae MF has a sub association Rotalidae-Nummulitidae and Nummulitidae MF has Nummulitidae-Rotaliidae sub microfacies. In the absence of features indicating distally steepened ramp, a homoclinal ramp, situated at about paleolatitude of 5°N, is envisaged in the underthrust crust of Indian Plate in warm tropical settings in Ypresian. The paleoecology of identifies LBF and microfacies analysis indicates that Margala Hill Limestone was deposited predominantly in subtidal conditions in inner to middle ramp settings. Cyclicity in these deposits is shallowing upward that indicates a high stand system tract.

GEOTHERMAL WELL OF RITTERSHOFFEN, ALSACE (GRT-1): AN EXAMPLE OF CUTTINGS AND FIELD ANALYSIS IN ORDER TO ESTABLISHE A VERY PRECISE GEOLOGICAL LOG

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Due to the Upper Rhine Graben (URG) system, the geothermal gradient is abnormally high in Northern Alsace (the temperature highlighted 50°C at 400 meters deep). These high temperatures added to the presence of natural brines (in the order of 100g/L) circulating in the fault system triggered different geothermal projects in Alsace region which is located in the north-eastern part of France. The URG is therefore one of the most studied region in Europe, mainly for petroleum exploitation and recently for geothermal applications like on the French side with the Soultz-sous-Forêts geothermal pilot site and the Rittershoffen industrial geothermal one. Between 2012 and 2014, at Rittershoffen, two new geothermal boreholes GRT-1 and GRT-2 were successfully drilled up to the granitic basement, final depth at 2562 m and 2707 m vertical depth respectively. The achievement of the Rittershoffen's geothermal doublet which was the subject of particular attention in the acquisition of a very precise stratigraphic profile, enabled the establishment of a 3 km-thick complete geological section from the Quaternary formations, through the Cenozoic and Mesozoic sediments down into the granitic Paleozoic basement. It is the first complete geological log of the entire sedimentary cover of the URG combining the succession of the formations including thickness with precise limits of top and base, age and sedimentary facies. It is the result of a close combination between cuttings and well data analysis, field campaign and the study of core samples. The first step was to establish the lithostratigraphic log of the borehole with the cuttings and well data. In order to be able to accurately define the precise geological limits, the second step was a field campaign based on relevant analogues to carry out fine resolution analysis of outcrops to refine the precision of the limits. And as a last step, the 400 m length of Buntsandstein cores samples were studied in order to find the objective limits in the sandstones formations, very difficult to differentiate with only the help of cuttings (it is a succession of pink sandstone formations similar one to the other). This precise geological log has allowed the complete stratigraphic reinterpretation of ancient geothermal wells (GPK-1, GPK-2). In addition, it will serve as a basis for future geothermal drilling operations scheduled end of 2017 in the Strasbourg area. This work permitted to precise the succession of geological facies between the formations and inside each formation.

GEOCHEMICAL, ASTRO-AND GEOCHRONOLOGICAL CONSTRAINTS ON THE BATHONIAN–CALLOVIAN BOUNDARY (NEUQUÉN BASIN, ARGENTINA)

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Middle Jurassic Bathonian–Callovian sections have been primarily studied in Europe, owing to a lack of appropriate biostratigraphically controled sedimentary archives elsewhere. Only two studies integrate carbon-isotope and ammonite biostratigraphical data across this stage boundary, one in Southern Iberia and one in Northern Italy, both sections being in relatively condensed calcareous pelagic facies. Furthermore, only a few studies have provided integrated geochronological and biostratigraphical constraints on Bathonian–Callovian sediments, with ages primarily derived from the Chacay Melehue Formation (Chacay Melehue, Neuquén Basin, Argentina). This section contains an expanded and continuous Pliensbachian to Oxfordian succession of rhythmically bedded mudstones interbedded with tuffs or tuffaceous sandstones. Ammonites are abundant throughout the section.

Here we present high-resolution carbon-isotope chemostratigraphy and hand-held X-ray fluorescence (XRF) data, integrated with ammonite biostratigraphy and new U/Pb single zircon geochronology from multiple ash beds throughout the succession at Chacay Melehue. The uppermost Bathonian in the Neuquén Basin is marked by a rapid transient negative shift in $\delta^{13}C$ values, from ~-25°/‰ down to ~-28‰. This excursion is followed by a gradual return to relatively heavier values of ~-24‰ in the Early Callovian.

The observed signature in $\delta^{13}C$values matches observations from Europe and potentially reflects a perturbation to the global exogenic carbon cycle rather than reflecting any change in the nature of the organic-matter source. In the Neuquén Basin this observed negative carbon isotope excursion (CIE) is marked by an increase in sedimentary total organic carbon values (TOC: up to 2.5%) and elevated molybdenum (Mo) and sulphur concentrations, suggesting a change in the redox state of the marine Neuquén Basin at that time.

Furthermore, the highly rhythmic sedimentary expression, reflected in periodic changes in majo-relement concentrations and ratios (Ca, Fe, Si, Zr etc) as well as $\delta^{13}C$ and TOC and redox-sensitive trace metals (e.g. Mo), suggests periodic changes in the depositional environment, possibly linked to astronomical forcing. With the integrated geochronological and astrochronological constraints we construct a temporally highly resolved framework for the environmental and depositional changes in the Neuquén Basin across the Bathonian–Callovian boundary, and for the potentially global carboncycle perturbation at this time.

We further hypothesize that the observed Bathonian–Callovian boundary events may be associated with extrusive volcanism in the Chon Aike volcanic province, which is considered one of the largest Silicic Large Igneous Provinces and which was still active in Argentina and Antarctica over this time period.

SEA-LEVEL CHANGES AND ITS EFFECT ON THE FORMATION OF OOILITIC RIDGES AT AL KHIRAN-SOUTH KUWAIT

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The Al Khiran area (southern part of Kuwait) is characterized by several parallel ridges mostly composed of oolitic limestones, quartz-oolitic limestones and oolitic sandstones. the highest of these ridges is at 8 m apsl and the lowest at 3 m; they both run parallel to the present Al Khiran beach. Petrographic evidence indicates a difference in the depositional environments for the limestones and sandstones. The top parts of each ride is composed of windblown oolitic and quartz oolitic limestone and sandstones, whereas the bottom part indicates a marine beach environment is composed of bioclastic-oolitic limestones made of bivalves and gastropod fragments. This is consistant with the field observation for the cross-beds within each ridge. The marine deposits are well preserved and made of ooid grains and shell fragments, whereas the aeolian beds are composed of diageneticaly deformed oolitic grains and lake bioclastic content.

Luminescence age dating of these ridges indicates that the more inland (beach ride 1) quartz-oolitic ridge formed 135 ±24 (135 ± on base k-feldspar) ky BP, whereas the most recent (beach ridge 2) oolitic ridge is 3 ±0.9 (3.1 ±0.5 k-feldspar) ky BP.

The provided age data open a new scenario on the evolution of Al Khiran oolitic beach ridges. They formed during the highest highstands of the last interglacial MIS5 (MIS5e) and the present interglacial (MISI). Elevation of both ridges is higher compared with world-wide elevation of similar deposits; that is, 4-5 m for MIS5e beaches and 0 m for the 3ky old beaches. This implies an active tectonism in the area since recent times. This tectonism could be related to the still active Zagros oroeny in the Kuwait area responsible of the uplifting of the studied oolitic beaches. If this were true, since 135 to 3 ky BP the uplifting rate was very low of about 0.003 mm/y, but that since 3ky BP to the present is was of about 1 mm/y.

SEQUENCE STRATIGRAPHY AND PLATFORM EVOLUTION OF THE SHAQRA GROUP JURASSIC OUTCROPS AND INTRASHELF ARABIAN BASIN, CENTRAL SAUDI ARABIA

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High-resolution sequence stratigraphic transects of the Jurassic Shaqra Group (Toarcian to Kimmeridgian) outcrops in Central Saudi Arabia outcrops provide a continuous stratigraphic record of a large (> 1000 km) epeiric, continental to shallow marine, tropical mixed carbonate-siliciclastic platform system. They serve as westernmost reference for adjacent prolific reservoirs in giant oil fields and intrashelf sourcerock bearing intrashelf basins. Several hierarchical stratigraphic sequences (second to fourth order) have been recognized in outcrops sections (600 km long south of Riyadh) and correlated with gamma-ray logs of subsurface wells (550 km long crossing the Arabian Basin from Riyadh to Rimthan Arch).

The Jurassic platform evolved from very-flat continental-to-nearshore mixed carbonate-siliciclastic platform (Marrat-Dhruma; Toarcian to Middle Callovian) to differentiated ramp platform with deep intrashelf basins (Tuwaiq-Hanifa; Middle Callovian to Early Kimmeridgian). Tectonic related siliciclastic influx took place in arid condition during the Kimmeridgian (Jubaila Fm.). The Jurassic platform evolution ends with the mixed carbonate-evaporite systems of the Arab Fm. A first second-order tectono-eustatic cycle (Marrat to Tuwaiq) is bounded at the base and top by regional unconformities. It has a stationnary depocenter, and show long-term coastal onlap and marine transgression that reached its maximum extent during the upper Tuwaiq Mountain limestone deposition. The Hanifa Formation consists of four 3rd-order sequences aggraded flattoped platform (outcrops to Khurais) marked at the base by nearshore argillaceous limestone and at the top by pure high energy carbonates with localized stromatoporoid build-ups. These shallow marine carbonates grade downslope to starved lime-mudstone intrashelf basin during maximum marine transgression (west Khurais to southern Rimthan Arch). The Jubaila-Arab-D is a 3rd-order sequence filling first the intrashelf basin with lowstand deposits and onlapping on top of the Hanifa Formation (Khurais to outcrop). These formed flat horizontal successions with lateral thickness variations controlled by differential subsidence that increases in the Arabian Basin. The transgression is marked by storm-influenced inner-platform with sandstone quartz, grainstones and restricted lime-mudstone. The maximum marine transgression is placed in the Arab-D with development of reef buildups in the westernmost inner-platform. During highstand, the reef facies are gently prograding out into Rimthan Arch at the top of the Arab-D.

For the first time, this detailed outcropping study reveals depositional models that subdivided the Shaqra group into genetically related sequences that are not always obvious from core, wireline logs or seismic data. Moreover, it provides significant understanding of the Jurassic history and tectonostratigraphic events of the Arabian Platform.

DOLOMITIZATION OF JURASSIC CARBONATES IN THE WESTERN HIGH ATLAS OF MOROCCO: PROCESSES AND IMPLICATIONS FOR RESERVOIR PROPERTIES

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Carbonate sedimentation during the Middle to Upper Jurassic along the Moroccan Atlantic margin is marked by the onset of marine conditions in the Callovian within the Agadir-Essaouira Basin. Field mapping suggests that dolomitisation is focused principally in the Oxfordian, on coral reefs. They are of particular interest as they constitute the only proven Jurassic carbonate reservoir so far offshore Morocco, in the Cap Juby field (Tarfaya Basin). The succession is overlain by a late Upper Jurassic succession of reddish marls and dolomites facies followed by peritidal limestones with evidence of emersion. This study integrates outcrop-based sedimentary logging and mapping of the dolomite, and its stratal relationships with detailed petrographical and geochemical analysis. The aim is to determine the processes that govern the presence and distribution of dolomite and assess its impact on reservoir properties. These data will then be used to construct predictive models for dolomitization in Jurassic strata from Morocco that can be extrapolated and applied to offshore exploration.

Initial field observations suggest that the Callovian-Oxfordian reefal dolomites are non strata bound, showing a close relationship to faults, often associated with highly fractured intervals. Some of the fractures are cemented and others remain open suggesting a complex history. Many are oil stained with a distinctive kerogenous odour. Moldic porosity and vugs are present and vary in intensity with distance from fault and between different dolomitized facies.

Petrographical study reveals the existence of planar, euhedral-subhedral and non-planar, anhedral dolomite textures within the Agadir-Essaouira basin. The Callovian dolomites consist mainly of subhedralanhedral crystals, often closely packed and fabric destructive. Fine-medium subhedral dolomite replaced the matrix, while blocky and sheared anhedral dolomites completely cement fractures. Blocky dolomites were also found lining or cementing vugs. Subhedral dolomites were concentrated along stylolites and scattered euhedral dolomites replaced ooids and part of the matrix with no observed micro-porosity. In localized areas, dedolomitization form fine-medium grained, recrystallized carbonates with subhedral crystal textures. Oxfordian dolomites were encountered in different facies. Planar, euhedral dolomites were scattered in mudstones, where dolomites selectively replaced the matrix. Zoned dolomites with local moldic porosity were found within wackestones. Polymodal, nonplanar, saddle, zoned dolomites showing cloudy centers and clear rims dominate grey and pink packstones. Ooidal grainstones were replaced mimetically by euhedral dolomites and accompanied by localized moldic porosity of these dolomites. Anhedral, saddle dolomite selectively replaced corals in reefal boundstones. Vugs and intercrystalline porosity were encountered in this facies. Intercrystalline porosity was created by dissolution of saddle dolomites. Vugs up to 1000 µm in diameter and fractures were filled by two cement phases: closely packed, fabric-destructive anhydral dolomites, followed by blocky non-ferroan calcite.

Based on the texture of dolomite and stratigraphic distribution, euhedral-subhedral dolomite is characterised as shallow subsurface/ low temperature (< 50°C). However, anhedral, fabric destructive dolomite is interpreted to be of higher temperature (> 50°C) and probably structurally controlled. Further petrographical and geochemical analysis would confirm the process and source of fluid that lead to dolomitization.

LARGER FORAMINIFERA BIOSTRATIGRAPHY OF THE EARLY MIOCENE CARBONATE PLATFORMS OF THE FALCÓN BASIN (NW VENEZUELA)

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The present contribution focuses on the early Miocene mixed carbonate-siliciclastic successions outcropping in northern and southern Falcón Basin (San Luis and Churuguara formations, respectively). The northern San Luis Formation is made up of an 800 meters thick succession of platform carbonates dominated by coralline algae, larger foraminifera and corals with interbedded deltaic deposits towards the basin margin, to the north. The southern Churuguara Fm. is represented by a 1,000 meters thick succession of siliciclastic marine deposits with interbedded carbonate banks characterized by the presence of larger foraminifera and coralline algae. The platform-carbonate banks are 10 to 100 meters thick and thin and pass southwards and eastwards into pelagic shales and turbidites, whereas towards the west the carbonates interfinger with shallow-marine siliciclastics. Larger foraminifera assemblages from both formations were studied on thin sections. The San Luis Fm. is characterized by an early Miocene larger foraminifera association including *Lepidocyclina favosa/undosa*, *L. canellei*, *Heterostegina antillea*, *Operculinoides panamensis*, *Miogypsina* aff. *mexicana*, *M.* aff. *gunteri*, *M.* aff. *globulina*, *M.* aff. *panamensis*, *M.* aff. *cushmani*, *Miosorites americanus* and *Annulosorites spiralis*. An equivalent early Miocene foraminiferal association was identified in the southern Churugara Fm., comprising *L. favosa/undosa*, *L. canellei, H. antillea*, *O. panamensis*, *M.* aff. *gunteri*, *M.* aff. *cushmani*, *M. americanus* and *A. spiralis*. The analysis of the distribution of *Miogypsina* species permitted a more accurate dating of both mixed carbonate-siliciclastic sucessions. In general, the lower part of the San Luis and Churuguara formations are characterized by a predominance of simple forms of *Miogypsina* with a low number of lateral chambers, whereas the upper San Luis and Churuguara formations are dominated by larger and more complex forms of *Miogypsina* with more layers of lateral chambers. The lower San Luis Fm. is interpreted as Aquitanian based on the occurrence of *M.* aff. *mexicana* and *M.* aff. *gunteri*, which have a biostratigraphic range comprised between the Chattian and the Aquitanian. The upper part of this lithostratigraphic unit was ascribed to the Burdigalian based on the absence of Chattian-Aquitanian forms and the exclusive occurrence of Chattian-Burdigalian forms including *M.* aff. *globulina* and *M.* aff. *cushmani*. The lower part of the Churuguara succession contains *M.* aff. *gunteri* which disappeared at the Chattian-Aquitanian boundary, whereas the upper part is characterized by the occurrence of *M.* aff. *cushmani*, ranging from the latest Chattian to the Burdigalian. The co-occurrence of exclusively Miocene species (e.g. *M. americanus* and *A. spiralis*) allowed us to interpret the age of the lower part of the Churuguara Fm. as Aquitanian and the upper part as Burdigalian. Prior to this work, the San Luis Fm. was either interpreted as Oligocene or early Miocene, and the Churuguara Fm. as Oligocene to early Miocene. The new biostratigraphical data, with *M. americanus* and *A. spiralis* occurring along the San Luis and Churuguara mixed carbonate-siliciclastic successions constrain the age of both formations to the early Miocene.

DIAGENESIS, MICROFACIES AND DEPOSITIONAL ENVIRONMENT OF THE ILAM FORMATION (ZAGROS FOLD AND THRUST BELT, WEST IRAN)

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The Ilam Formation (SantonianCampanian), which is part of the Upper-Cretaceous Bangestan Group, host several carbonate petroleum reservoirs in Iran. This widespread formation is exposed in the W to SW of Iran, within the Zagros fold and thrust belt. Microfacies diversity, sedimentary environment and diagenetic processes have been investigated from a reservoir point of view. The succession was studied on the one hand, using drill-core No. 12 of Tange Bijar with a thickness of 272 meters and, on the other hand, by inspecting outcrops with a total thickness of 172 m in Kuh-e-Shah Nakhjir in the Ilam region (west Iran) nearby the Tange Bijar oil fields. Macro- and micro-scopical petrographic analysis of depositional textures and fauna assemblage allowed to differentiate five microfacies in the field, and two microfacies in the drillcore. The microfacies identified during the field study include: 1) *Heterohelix*, *Globotruncana, Macro-globigerinelloides* Wackestone; 2) Oligosteginid, *Macroglobigerinelloides*, *Heterohelix* Packstone; 3) *Heterohelix*, *Globotruncana*, *Marginotruncana* Packstone; 4) *Heterohelix, Macroglobigerinelloides* Packstone; 5) *Globotruncana, Heterohelix, Marginotruncana* Wackestone/Packstone. The drill-core study, allowed to identify: 1) *Macroglobigerinelloides, Heterohelix* Wackestone; 2) Mudstone. We interpret the drill-core sections as a deeper stratigraphic level, explaining the observed difference in microfacies. The prevalent presence of planktonic foraminifera in mudstone suggests an open marine depositional environment. The lack of detrital debris and turbidites indicates a broad, gently-sloping carbonate ramp reflecting a is low-energy setting. In addition, the carbonate formation is influenced by early-to late-diagenetic processes such as compaction, stylolitization, hematitization, cementation, micritization, microfracturing and porosity development (intraparticle, vuggy and fracture). Both major and trace element geochemistry analyses give us more insight into the nature of the diagenetic system. Plotting Sr/Ca versus Mn, pointed that the diagenetic system in the Ilam Formation can be defined as closed to semi-closed.

AN INVESTIGATION INTO HOLOCENE AND ANTHROPOCENE PALEOLIMNOLOGY RECORDS TO IDENTIFY DRIVING FORCES OF EROSION AND RUNOFF IN MOUNTAINOUS CATCHMENT AREAS (PYRENEES, FRANCE)

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Significant research has been undertaken over the past two decades to identify and delineate flood event and long-term runoff erosion during the Holocene period. Recent published work focused in the French Alps and Pyrenees has illustrated capacity to use lacustrine sedimentary infill, reconstituted from dated lake core samples, to discuss Holocene (and earlier) runoff and flood occurrences within alpine catchments. Lake sediments trap various paleolimnology proxies, which can be examined to paint a detailed picture of humanclimate-environment interactions over time. Among them, quantitative organic petrography, in combination with age-depth modelling, gives us the possibility to estimate the amount of soil eroded within the catchment through time. In mountainous areas, such erosion fluxes are expected to be essentially driven by rainfall and runoff (energy and climate drivers). The work-package 5 from the TRAM research project proposes to study the sedimentary infill from Lake Arbu, a small high-altitude system of glacial origin located into the French Pyrenees, in order to investigate the potential of the paleo-limnological dataset to provide clear runoff and erosion proxies potentially capable of long-term semi-quantitative catchment erosion analysis. Combining sediment accumulation rates with quantitative organic petrography, and hydrological dynamics (rainfall and runoff characteristics) longer-term sediment mass balance analysis can be completed. De Ploey's Cumulative Erosion Potential (CEP) presents one such simple mass balance model. Similar to the earlier USLE, CEP provides a mass balance analysis based on rainfall (and discharge) datasets, providing consideration of soil moisture capacity (i) and erosion susceptibility (Es) for a selected catchment. Correlation analysis of sediment accumulation rates with mass balance expected deposition, key mass balance parameters (including CEP, Es and the RUSLE K), sediment, land use and climate characteristics is a first step in identification of possible paleo-limnological contributing catchment erosion rate proxy definition. Where no single parameter has indicatively been found to effectively represent fine sediment deposition in the investigated mountain catchment sinks (lakes and peat), use of multiple regression and principal component/canonical correspondence analysis (PCA/CCA) is implemented to identify key forcing parameters. The correlation and statistical analysis initially undertaken is the first step towards long-term sediment transport modelling to represent alpine catchment runoff and erosion over the Holocene time period, with the potential to consider future long-term or rapid climate change impacts on the mountain critical zone.

SALTGIANT: A EUROPEAN TRAINING NETWORK DEDICATED TO UNDERSTANDING THE MEDITERRANEAN SALT GIANT

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As society moves into an era where environmental change has an ever-growing place in the political agenda, the demand for a new generation of scientists working at the interface between the natural and social sciences is growing. SALTGIANT contributes to satisfy this demand within a rare cross-disciplinary network of natural and social scientists dedicated to understanding the formation of the Mediterranean Salt Giant, one of the largest salt deposits on Earth, and its implications for subseafloor microbial life, risk assessment in the oil industry, geo-economics of the Mediterranean region and the history of oceanography. Starting on February 2018, for 4 years, SALTGIANT will bring together 23 academic organizations (12 beneficiaries, 11 partners), 6 private sector Oil&Gas companies, 2 mining sector companies, 1 biotechnology company, 1 geopolitics think tank and 1 specialist in transferable skills training from 11 countries to stimulate interdisciplinary and intersectorial knowledge exchange between geologists, geophysicists, geochemists, microbiologist, geographers and historians in a network with PhD students at its core. SALTGIANT combines (i) geological field work, (ii) laboratory measurements and experiments, (iii) numerical modelling at a wide range of spatial and temporal scales and (iv) empirical social sciences data collection and analysis, guaranteeing exposure of the research fellows to state-of-the-art scientific knowledge and hands-on practical training in a field rich in applications of both intellectual and societal relevance. Through its innovative blend of training and research activities, SALTGIANT will boost the employability of its research fellows in academia and in the private sector, particularly the energy sector, including Oil & Gas and geothermal, resource management, geological storage and numerical modelling, as well as in governmental agencies (Ministries of the Environment, Sustainable Development and Energy), international organizations (European Environment Agency, EEA; United Nations Environmental Program, UNEP) and NGOs.

DATING THE ANTHROPOCENE IN DEEP-SEA SEDIMENTS: A GAMMA SPECTROMETRIC APPROACH

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The understanding of sedimentation rates in open ocean areas was a milestone achievement for the deep-sea biogeochemistry. Dating back the beginning of the Anthropocene (in terms of Crutzen & Stoemer) is relatively easy in strongly industrialized areas and coastal zones, whereas it becomes more complicated in remote offshore deep-sea basins. More precise dating techniques are therefore required for the open ocean. Establishing an accurate sediment chronology for ocean sediments has inherent complications, as certain methodological constrains that occur during the offshore sampling processes and the dating techniques can lead to a reduction of the resolution's quality, which in turn is important for identifying the commencing of anthropogenic processes.

We are presenting a novel approach based on low level background gamma-ray spectrometry with two hyper-pure germanium (HPGe) detectors, allowing for an optimal chronological framework based on ^{210}Pb dating. This method can be applied to date sediments from the last 150-200 years, by using ^{210}Pb (T1/2= 22.23 yr), a natural radionuclide. Furthermore, it is a non-destructive technique and facilitates information on all gamma emitters present in the sediments (^{226}Ra, ^{234}Th, ^{137}Cs, ^{241}Am). Surface sediment cores were sampled across the Irminger Basin (North Atlantic Ocean) in June-July 2016 during the BOCATS/OVIDE-2016 cruise aboard R/V Sarmiento de Gamboa. The selected, well-preserved core (59.49° N, 37.68°W, 3110 m depth, Central Irminger Sea) was sliced on board (0.5 cm when available, until centimeter 10) and stored in a refrigerator at 4°C. Oven dried samples (45 ±2°C) were powdered in a ball-mill and sealed into plastic containers at least three weeks before their radionuclide activities were counted. The radionuclide activities of 30 individual samples were measured within 48-96 hours, until statistically significant emissions' spectra were achieved. The fundamental principle of the dating models is the higher affinity of ^{210}Pb for organic matter and suspended particles, resulting in an excess of ^{210}Pb withrespect to ^{226}Ra within the sediment.

The technique proved to be accurate and sensitive enough, and for the Irminger core the first 13 cm of sediment represent approximately 140 years, under a Constant Rate of Supply (CRS) model. Minimum detectable activities (MDA) were below 0.6 $Bq \cdot kg^{-1}$, 0.56$Bq \cdot kg^{-1}$ and 2.26$Bq \cdot kg^{-1}$for ^{210}Pb, ^{214}Pb and ^{226}Ra, respectively. Based on this chronology, the average sedimentation rate of the core is 0.83 ± 0.13 mm/year, which results quite high for a deep-sea basin. ^{210}Pb dated profiles allowed us to estimate the amount of material exported from the water column to the sediment: 30.8 ±4.6 $Bq \cdot m^{-2}$ or 829.3 ±99.6 $g \cdot m^{-2} \cdot y^{-1}$. Combining this valuable information with the high resolution elemental analyses obtained with a LECO CN, provide first estimates of total inorganic/organic carbon accumulated during the Anthropocene. We conclude that during the last 150 years 31.9 ±14.3 g $Cinorg \cdot m^{-2} \cdot y^{-1}$ and 4.5 ±2.8 g $C_{org} \cdot m^{-2} \cdot y^{-1}$ are being deposited in the Irminger Sea, generating a substantial carbon sink in the area of more than 22 Tg $C \cdot y^{-1}$.

SUBMARINE SLIDE BLOCKS: THREE-DIMENSIONAL STRUCTURES WITH IMPACT ON SEAL COMPETENCE

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This talk will use high-quality three-dimensional (3D) seismic and outcrop data to review the significance of deformation structures in mass-transport deposits (MTDs) across a variety of geological settings. On multiple continental margins, modern and old, blocky MTDs generated during major instability events pose the largest risk in terms of seal competence in hydrocarbon-rich basins. By definition, blocks exceed 4.1 m in length and can be ~500 m high by > 4.5 km long on margins such as SE Brazil's, West Iberia, in tectonically active parts of SE Asia, and along salt-rich slopes along the Gulf of Mexico, Mediterranean Sea and West Africa.

The emphasis of the talk will be on upscaling deformation structures found at distinct portions of blocks from seismic to outcrop. Of definite importance is the presence of faults, fractures, foliated strata, intrafolial folds, tiling, bookshelf sliding and dilational jogs, all structures that reflect important shearing within blocks and their basal glide planes. These features are accompanied by sand injection features, loadflame structures and remobilised sand 'layers' at the base of the blocks.

An important observation from multiple outcrop locations in Europe is that blocks are often translated above a shear plane composed of polymictic breccias, and other deformed strata. Rolled and translated limestone clasts occur within these polymictic breccias, which can present a matrix varying from clay to coarse-sand/pebbles. This complex structure puts in question the morphology of basal glide planes as we interpret them on seismic data and highlights the presence of porous strata at the base of large MTDs. In addition, several other intervals with evidence for sand injection and sediment remobilization under high fluid pressures are observed inside the blocks themselves, hinting at local fluid overpressures.

The talk will show that buried MTD blocks and associated coarse-grained debrites are capable of forming prolific intervals in which hydrocarbons and mineralized fluid will migrate into. The presentation will show that three-dimensional leakage factor models show the bulk of fluid flow to be focused in vertical and horizontal surfaces within, and immediately below displaced blocks. The generation of large slide blocks can also mark the sudden release of overburden pressures, and result in the loss of seal competence above existing hydrocarbon fields. Models based on seismic and outcrop observations are presented to corroborate these latter postulates.

Ultimately, the presentation will clarify the present-day understanding on the modes of formation of submarine slide blocks, confirming their economic importance in deep-water basins throughout the world.

PALAEOENVIRONMENTAL RECONSTRUCTION OF THE GUERCIF BASIN DURING THE TORTONIAN-MESSINIAN (NE MOROCCO)

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The Guercif basin located in the eastern part of the South Rifian Corridor (NE Morocco), is among the important basins for understanding the water exchange between the Atlantic Ocean and the Mediterranean Sea during the upper Tortonian and early Messinian.

The present work aims to: i) establish the clay mineralogical and geochemical characteristics of the sedimentary deposits of the Neogene series of the Guercif basin; i) determine the respective influences of inheritance and diagenesis of clay minerals in the sediment deposited in the basin; iii) highlight the paleogeographical evolution of this basin as well as the environment of sedimentary deposits. For this purpose, a complete geological cross-section was investigated in the southwest of the basin, including the succession of the Tortonian-Messinian series ended by continental deposits of Pliocene age. Three lithological units are deciphered from the bottom to the top: biocalcarenite, marl-clay alternations and gypsiferous marls.

The vertical distribution of clays shows four mineralogical zones, covering upper Tortonian to Messinian, were identified. Hot and humid zone I is attested by the occurrence of illite and chlorite with a low amount of kaolinite. Zone II remains hot but with seasonal contrast characterized by the occurrence of smectite. Zone III was arid as marked by the appearance of palygorskite associated with smectite. Zone IV from the Messinian was hot and arid with contrasted season as attested by a relative increase in smectite, palygorskite and illite/smectite mixed layers, while illite and chlorite decrease. The Tortonian biocalcarenitic sediment contains a higher carbonates content ($CaCO_3$ 60% wt.) than the Messinian gypsiferous marls (19%). In addition, the high SiO_2/Al_2O_3 ratio (average of 4.72) indicates a high detrital input and therefore confirms the arid environmental conditions over the Messinian.

EROSION AND SEDIMENT TRANSPORT BY DENSE SHELF WATER CASCADES

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Downslope flows of dense shelf water (DSW), also known as dense shelf-water cascading (DSWC), are an important oceanographic process that occurs along some polar and temperate margins. DSWC starts when surface waters over the continental shelf become denser than surrounding waters due to cooling, evaporation, sea-ice freezing and/or deep sub-ice shelf melting. The dense water mass then sinks and flows seaward as a near-bottom (thermohaline) gravity-driven flow. DSWC can result in a massive transfer of energy and matter from shallow to deep waters and can cause appreciable seafloor erosion and sediment transport. Field observations show that DSWC can rapidly reshape the seafloor, particularly in submarine canyons. It has also been suggested that DSW fluxes could be the origin of some of the continental slope gullies observed on Polar continental margins. Though these studies have led some to invoke DSWC as an explanation for geomorphic features on continental margins, a systematic investigation of DSWC hydrodynamics and sediment transport is lacking. In situ near-bottom velocities of up to 1.25 m/s have been measured for DSW flows. These velocities are comparable to those observed in turbidity currents, but suspended sediment concentrations tend to be much lower (~ 0.002 to 0.005 g/l) in DSWC. Because they are dilute, sediment transport by DSWC flows has largely been ignored, especially when compared with other sediment-laden currents. However, the water volumes transported by DSWC events are exceptionally large, as these flows typically last for days to weeks and can even be sustained for months in some polar regions. To better understand how DSWC events of varying size and duration interact with variable seafloor topography and erodability, we will present modelling results based on a depth-integrated formulation developed to represent turbidity currents (Nixes-Tc model, developed at LGS-IFREMER). Several runs using varied sets of flow parameters, boundary conditions and generic terrain models will allow us to compare the differences in erosion and sediment transport between DSWC and turbidity currents.

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EVOLUTION OF CENTRAL TETHYAN CARBONATE PLATFORMS BEFORE AND AT THE ONSET OF OCEANIC ANOXIC EVENT (OAE)1A: TIMING OF BIOTIC AND ENVIRONMENTAL CHANGES

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Shallow-water carbonate sediments are sensitive but complex archives recording biosphere-hydrosphere geosphere interactions produced by a variety of local, regional and global processes. These archives are often incomplete and with insufficient age control. New stratigraphic tools, including chemostratigraphy, were used to improve the correlation with deep water pelagic counterparts that are more accurate and complete documents of paleoceanographic and paleoclimatic changes. In fact, a new C-isotope stratigraphy combined with a revised litho-and biostratigraphy of Barremian-Aptian platform carbonates from the central-southern Apennines (Italy) has been carried out at localities Santa Maria (Abruzzi Region) and Monte Faito (Campania Region). These sections serve as archives of platform evolution during a time of major C-cycle perturbation before and during Oceanic Anoxic Event (OAE)1a. These successions are correlated at a regional scale with the Monte Raggeto reference section (Campania Region) where the Selli Level Equivalent (SLE) and the Magnetic Polarity Chron CM0r were recognised in earlier studies. Significant biotic and environmental changes are documented within the Late Barremian-Early Aptian interval; in particular, the Palorbitolina lenticularis-Lithocodium-Bacinella association followed by dark-brown microbial sediments reflect considerable ecological stress upon the oligotrophic carbonate platform community (mesotrophic or even eutrophic conditions) which precedes the onset of SLE by at least 1.2 Myr.

No evidence for drowning of the Apennine and Apulia platforms during the Early Aptian is documented, but significant changes of environmental conditions appear to culminate at the beginning of negative excursion C-3 in the Early Aptian C-isotope curve.

Moreover, this integrated approach has resulted in an improved age control which offers the opportunity to correlate the Apenninic sections with a succession from the French Urgonian platform (Cluses section) and with pelagic records from the Italian Umbria-Marche (Gorgo a Cerbara) and Belluno (Cismon Apticore) Basins. Pelagic biozonations and magnetostratigraphy have been projected into carbonate platform sequences.

A prevailing eustatic origin has also been attributed to some of the lower-frequency transgressiveregressive cycles (T/RFTs) that reflect third order sea-level oscillations. Based on the orbital chronostratigraphy, durations of the stratigraphic, isotopic and magnetostratigraphic events have been estimated and show good agreement between neritic and pelagic domains.

The new correlations indicate that comparable biotic and environmental changes, documented around the Tethys, are not always synchronous. The first signs of perturbed biocalcification are recorded in northern Tethyan sediments of latest Barremian age and the northern Tethys ecosystem was more severely affected by changing Barremian-Aptian climate than the southern Tethys. The type of response of biota to C-cycle perturbations before and during OAE1a depends upon palaeolatitude, palaeogeography, palaeobathymetry and regional climate patterns.

INNOVATIVE & CLASSICAL METHODS FOR THE STUDY OF MINERALOGY OF TURBIDITES IN ONGOING AND FUTURE IODP EXPEDITIONS

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The scientific drilling of oceanic sedimentary sequences plays a fundamental part in provenance studies, paleoclimate reconstructions, and source-to-Sink investigations. A high-resolution mineralogical study of Indus Fan turbiditic sediments cored during IODP Expedition 355 (Arabian Sea Monsoon) in the Laxmi Basin was carried out to investigate and quantify the different compositional signatures of sand and silt fractions. Silt and sand in turbidite deposits recovered at IODP Sites U1456 and U1457 were chosen as the best natural archive for this source-to-Sink study.

Heavy-mineral species commonly found in sediments convey specific information on the genesis of their source rocks and are therefore crucial in provenance diagnoses and palaeotectonic reconstructions. An integrated mineralogical dataset was obtained by coupling traditional and innovative single-grain heavy-mineral analyses. Reliable quantitative results even in the medium to fine silt classes, which represent the dominant sediment sizes encountered in the recovered cores, were obtained by point counting of single grains under the microscope assisted by Micro-Raman spectroscopy. When studying oceanic deposits, Raman spectroscopy can and does represent an essential flexible tool for the multidisciplinary approach necessary to integrate the insight provided by different disciplines. Raman spectroscopy allows us to identify silt-sized grains down to the size of a few microns with the same precision level required in quantitative provenance analysis of sand-sized sediments.

Preliminary data from the studied turbidites document rich and diverse heavy-mineral assemblages in both sand and silty-sand fractions. Multiple varietal studies of amphibole, epidote and garnet varieties, representing the dominant heavy-mineral triad in orogenic detritus derived from collided ranges such as the Himalaya, were performed to highlight the wide unexplored potential of Raman spectroscopy when applied to provenance studies. A protocol to separate heavy minerals from the silt fraction, starting from a few grams of sediments only, was developed at the Laboratory for Provenance Studies of Milano-Bicocca. An appropriate data base of Raman spectra of detrital minerals is essential to apply this method routinely in future provenance studies of deep-sea turbidites.

Such a new methodological approach plays a key role to differentiate among the diverse Himalayan versus Indian Peninsular sources of detritus and opens up a new frontier for future studies of the largely unexplored deep-marine sedimentary record.

THE COMPLEX DIAGENETIC HISTORY OF DISCONTINUITIES IN SHALLOW-MARINE CARBONATE ROCKS: NEW INSIGHTS FROM IN SITU δ^{18}O, δ^{13}C AND REE MEASUREMENTS BY SIMS AND LA-ICPMS-HR

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Sedimentary gaps are challenging barriers for the reconstruction of carbonate platforms history, and then for the characterization of their sequence stratigraphy, architectural and palaeoenvironmental evolution. In order to improve the understanding of the early diagenetic events occurring during the formation of discontinuity surfaces in limestones, Secondary Ion Mass Spectrometry (SIMS) and high resolution mass spectrometry coupled with laser ablation (LA-ICPMS-HR) were used for the first time together to measure the δ^{18}O, δ^{13}C and REE signatures of 12 early cement and fabric stages in several surfaces from the Jurassic platform of the Paris Basin. The early cement stages investigated clearly display different characteristic REE signatures, as for meniscus and pendant cements. Meniscus cements display a negative cerium anomaly while they precipitated in meteoric water, as attested by their very negative δ^{18}O signature (-4.3‰). Pendant cements show a high variability in δ^{18}O, which was not possible to detect using the conventional but less precise microdrilling method. We demonstrate that a given cement morphology can form in different environments: dogtooth cements are for instance observed in marine phreatic and meteoric phreatic to vadose environments, as shown by their varying δ^{18}O signatures. Marine dogtooth cements and micritic microbially-induced fabrics precipitated directly as low-magnesium calcite in marine waters, as attested by the preservation of their initial δ^{18}O and δ^{13}C signatures. Based on high-resolution geochemical analyses of early cements and fabrics, five discontinuity types were recognized and their palaeoenvironmental history could be reconstructed. Two exposure surfaces with non-ferroan pendant or meniscus cements formed in an oxidizing vadose zone. A hardground displays marine fibrous cements and non-ferroan dogtooth cements that formed in a subtidal environment in oxidizing water. Two composite surfaces were affected by marine and subaerial lithification. Composite surface 1 displays non-luminescent ferroan dogtooth cements that precipitated in reduced seawater conditions, followed by brown-luminescent dogtooth cements characteristic of a meteoric phreatic environment. Composite surface 2 exhibits microbially-induced fabrics that formed in marine water with abundant organic matter. The latter discontinuity, initially formed in a subtidal environment, was subsequently exposed to meteoric conditions, as evidenced by ferroan geopetal cements. This study shows that a high-resolution ion microprobe and LA-ICPMS-HR studies are essential to precisely document the successive diagenetic environments that have affected carbonate rocks and discontinuities with a polygenic and intricate history.

EVOLUTION OF THE PYRENEAN AQUITAINE FORELAND BASIN (SW FRANCE)

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The Aquitaine basin is the retro-foreland basin associated with the Pyrenean orogen. It developed from Campanian to Mid-Miocene by flexure of the upper (European) plate. The foreland basin forms a synorogenic sedimentary wedge up to 5.5 km thick in the south, thinning rapidly north. The synorogenic series migrates northward. The paleo-geographic history of the Aquitaine Basin shows an evolution from deep marine to continental facies. The continental to marine transition also migrates to the west. We study the spatio-temporal evolution of tectonic subsidence in the Aquitaine foreland basin, in order to understand the role of different sources of subsidence at each stage of basin evolution. Our analyses show that the tectonic subsidence in the Aquitaine Basin is a combination of flexural subsidence, caused by the Pyrenean orogen and dense mantle bodies within the upper crust, and post-rift thermal subsidence inherited from Early Cretaceous rifting. The post-rift thermal subsidence increases westward, reaching its maximum above inherited rift-basins (Parentis and Arzacq rift-basins). In the central Aquitaine Basin, two foreland successions are recognized, corresponding to distinct stages in the tectonic evolution of the Pyrenean orogenic system. The first succession (Campano-Maastrichtian) was deposited during the early inversion of the rifted domain. Early loading on the southern part of the European plate was synchronous with post-rift thermal subsidence during this stage. The second foreland succession (Eocene to Mid-Miocene) was deposited during main continental collision of the Pyrenees. These two foreland successions are separated by a Paleocene quiet phase. We show that the inherited thermal subsidence strongly influenced facies distribution and the evolution of the flexural Aquitaine foreland basin.

SUBSIDENCE ORIGIN, LATERAL VARIATION IN FORELAND EVOLUTION, AND FLEXURE OF A RIFTED CONTINENTAL MARGIN: THE AQUITAINE FORELAND BASIN (SW FRANCE)

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We study the effects of the inherited Aptian to Cenomanian rift on crustal rheology and evolution of the Late Cretaceous to Neogene flexural Aquitaine foreland basin, northern Pyrenees. We use surface and subsurface geological data to define the crustal geometry and the post-rift thermal subsidence, and Bouguer gravity anomalies and flexural modeling to study the lateral variation of the elastic thickness, flexure of the European plate and controlling loads. The Aquitaine foreland can be divided along-strike into three sectors. The eastern sector is un-rifted and is associated with a simple flexural subsidence. The central sector is affected by crustal stretching and the observed foreland base is modeled by combining topographic and buried loads, with post-rift thermal subsidence. In the western sector the foreland basin geometry is mainly controlled by post-rift thermal subsidence. These three sectors are separated by major lineaments, the Eastern and Western Crustal Lineaments, which affect both crustal and foreland geometry. These lineaments seem to be part of a larger structural pattern that includes the Toulouse and Pamplona Faults. The European foreland shows lateral variations in flexural behavior: the relative role of surface and sub-surface (i.e., buried) loading varies along-strike and the elastic thickness values decrease from the north-east (25 km) to the south-west (7 km) where the plate is the most stretched. We suggest that foreland basins are influenced by the thermal state of the underlying lithosphere if it was initiated soon after rifting and that thermal cooling can contribute significantly to subsidence.

STRATIGRAPHY, MINERALOGY, AND ORIGIN OF LAYERED DEPOSITS IN THE NORTHERN RIM OF HELLAS BASIN, MARS

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The Mars surface shows morphological and geological clues (e.g. valley networks, delta and alluvial fans...), suggesting that liquid water has been present during a long early Martian period of time (> 200 Myr), at the end of Noachian epoch (~3.8 Ga). In the northern rim of Hellas basin, these geomorphologic clues are less obvious because the pristine geological features are partially buried or eroded. This region shows a highly cratered landscape in which smooth plains are standing between large degraded impact craters.

However, from orbital imagery whose spatial resolution ranges from ~100 m/pixel to 25 cm/pixel, it is possible to identify light-toned layered deposits, located mainly in erosive windows inside intercratered plains and large degraded impact craters like Terby and Niesten craters. The geometry of layered deposits is consistent with that of clastic sediments that settled mainly in aqueous environments (e.g. lake or ocean). These layered deposits are mainly composed of hydrated minerals, including Fe/Mg phyllosilicates, supporting this type of aqueous sedimentary environment.

For example, inside 175 km-in-diameter degraded Terby impact crater located at the northeastern part of Hellas rim (28.0°S74.1°E), the sedimentary filling shows a conical shape with its apex on the northern rim and its distal zone to the center of impact crater. From erosional cross-sections, the inner geometry of thickest layered deposits is similar to that observed in terrestrial fan deltas, as identified by 100 m to 1 km long clinoforms, as defined by horizontal beds passing to foreset beds dipping by 6°-10° toward the center of the impact crater. The identification of distinct aqueous fan sequences, separated by unconformities and local wedges, showed the accumulation of sediments from prograding/onlapping depositional sequences, due to lake level and sediment supply variations. The volume of fan sediments was estimated as > 5,000 km^3 which is a large amount of clastic material considering classical Martian fan deltas such as Eberswalde (6 km^3) whose morphological signature is well preserved.

In 100 km-in-diameter Niesten crater located at the northwestern part of Hellas rim (28.3°S– 57.7°E) and its neighbor, the layered deposits shows four main sedimentary sequences, with a low (< 6°) dip to the center of impact. However, the sedimentary filling is extending beyond the northern degraded rim in relation with inter-crater plains. This suggests that the sedimentary process is regional.

In the inter-crater plains, layered deposits are observed mainly in erosional windows. In some of them, low dip layers are cross-cut by filled 100 m wide, 6 m deep channels, suggesting that one part of sedimentary clastic material would have been transported by water fluid (rivers or sub-marine flows).

As layered deposits observed inside inter-cratered plains and large degraded impact craters in the northern Hellas rim show evidence of deposition in aqueous environments (delta fans, channels,...) at the end of Noachian (3.8 Ga), this implies that they were formed in a sustained liquid water activity at the Martian surface, involving liquid water exchange between surface, atmosphere and lithosphere during a long period of time, favoring alteration, mechanical erosion, transport and deposition processes.

STABLE ISOTOPE ($\delta^{13}C$ AND $\delta^{18}O$) COMPOSITION OF FRESHWATER MOLLUSC SHELLS AND ITS APPLICATION IN PALAEOLIMNOLOGICAL STUDIES

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Carbon ($\delta^{13}C$) and oxygen ($\delta^{18}O$) stable isotope analyses are among the standard methods applied in the studies of past environment, including climate. In lacustrine sediments $\delta^{13}C$ and $\delta^{18}O$ values can be measured in fine carbonate fraction (carbonate mud), in charophyte encrustations, ostracod carapaces and mollusc shells. Application of the stable isotope record of each of the above-mentioned components of the lake sediment requires knowledge about possibilities and limitations of the method. The present research discusses the most important results of the studies carried out between 2011 and 2013, concentrated on the stable isotope composition of snail shells, primarily, the species commonly preserved in central European Quaternary lacustrine sediments. The stable isotope studies involved also, the zebra mussel (Dreissena polymorpha), one of the most invasive freshwater species in the world. The research involved shell isotope studies of both recent and fossil molluscs derived from the Holocene sediments.

Shell $\delta^{13}C$ values were species-specific and among the gastropods studied the same order of species from the most to the least ^{13}C-depleted was observed at all sites sampled. Shell $\delta^{18}O$ values were more uniform. A wide range of $\delta^{13}C$ and $\delta^{18}O$ values were observed in population and subpopulation, i.e., when live snails were sampled live from restricted area within the lake littoral zone. Carbon and oxygen stable isotope values of the mono-specific shells sampled from 1 cm thick sediment samples were highly variable. Those intra-specific differences (n=20) were as large as several permill. Such significant variability in $\delta^{13}C$ and $\delta^{18}O$ values indicates that stable isotope composition of single shells is unlikely to be representative of the sediment sample.

In conclusion, samples of fresh water molluscs for stable isotope analyses should be monospecific and composed of at least several shells. The number of shells being dependent on the difference between the minimum and maximum values within the sediment layer.

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SEASONAL CHANGES, SPATIAL VARIABILITY AND ORIGIN OF SUSPENDED ORGANIC MATTER IN AN ARCTIC FJORD (HORNSUND, SPITSBERGEN)

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Temporal and spatial variability, as well as sources of particulate organic carbon delivered to the sediments of an Arctic fjord can be recognized using carbon stable isotope composition ($\delta^{13}C$) of suspended organic matter (SOM). This method was applied in Hornsund fjord, Spitsbergen. Sampling was carried out between May 2015, when most of the investigated area was covered with sea-ice, and late August 2015. Samples were taken from a number of sites in central part of Hornsund, Burgerbukta, Samarinvegen and Brepolen bay in the innermost part of the fjord. One litre water volume, sampled from a range of depths between the water surface and 100 m, was filtered using GFF filters. $\delta^{13}C$ values of the SOM were measured after acid treatment of the filters to remove carbonates. $\delta^{13}C$ values of SOM varied both temporarily and spatially reflecting the variable sources of organic carbon, namely the marine production in situ, fresh marine organic carbon brought from the shelf with currents and carbon delivered from land, including both, the old sedimentary carbon and detritus of recent terrestrial vegetation. The samples were most ^{13}C-enriched (-22.4‰) in June, at the time of an intensive primary productivity within the fjord. Later, during the warm season, with the more intensive glaciers melting and thus supply of the suspended sediment load containing carbon from the land sources, $\delta^{13}C$ values of SOM decreased in all the localities studied towards the carbon isotope values of the local terrestrial end-member, i.e., $\delta^{13}C$ values of the old organic carbon in the bedrock and recent terrestrial vegetation. Change in $\delta^{13}C$ values of SOM was also observed with increasing distance from glaciers, e.g. in front of the Samarinbreen, and reflect changes in the intensity of primary production and supply of the carbon from land sources.

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OLD, LAND-DERIVED ORGANIC MATTER AS A PRIMARY SOURCE OF THE ORGANIC CARBON TO THE SEDIMENTS OF HORNSUND FJORD, SPITSBERGEN, AS EVIDENCED BY $\delta^{13}C$ VALUES

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Fjords have been for a long time considered as sediment and organic carbon (OC) depocenters. It has been estimated that the amount of OC buried in fjords may be as much as one tenth of the total OC in marine sediments. Good understanding of sedimentary processes and sources of OC is necessary to accurately estimate OC burial in fjords and their role in the sequestration of atmospheric CO_2. In the present study, we aim to determine the origin of the OC in the sediments in Hornsund fjord, Spitsbergen. The subpolar fjords of Svalbard are of particular interest because of the rapid retreat of tidewater glaciers observed after termination of the Little Ice Age around 1900 AD and formation of new bays characterized by high sediment accumulation rates in the inner parts of the fjords.

OC in the fjord sediments is derived from two major sources, old organic matter (OM) from land and fresh, marine OM, from the primary producers in particular. The relative share of land-derived OM and the OM of marine origin can be determined by comparing the carbon ($\delta^{13}C$) isotope values of sedimentary organic matter (SOM) with $\delta^{13}C$ values of land and marine end-members. For Spitsbergen, average $\delta^{13}C$ values of the two end-members were determined as -27‰ and -20.6‰, respectively. However, considering the variable bedrock of the Hornsund fjord catchment, including limestones and dolostones, and a range of clastic sedimentary rocks: conglomerates, sandstones, siltstones, shales and bituminous and black shells, of Early Palaeozoic to Neogene age, we have hypothesized that the generally accepted and applied in the OC mixing lines, average $\delta^{13}C$ values of the land end-member are far too general.

To test our hypothesis two set of samples were collected: surface sediments from bays within the inner part of the Hornsund fjord, namely Burgerbukta, Samiarinvogen and Brepolen; and samples of the land end-member including diamictons, sediments from river beds, deltas, and beach sand were collected from the shores of the Hornsund fjord. The samples were analyzed for $^{13}C/^{12}C$ ratios with Flash ThermoQuest (1112) analyzer with an Isotopic Ratio Mass Spectrometer Finnigan MAT 253 (ThermoQuest).

We found a close correspondence between the $\delta^{13}C$ values of the local land-end-member and $\delta^{13}C$ values of the OC in the fjord sediments. The most ^{13}C-enriched SOM and land end-member were found in Brepolen, -24.8‰ and -24.2‰, respectively, whereas the most ^{13}C-depleted OC was found in Burgerbukta, -26.6‰ and -25.8‰, respectively. The results evidence the petrogenic, land-derived organic matter as the primary source of OC to the sediments in Hornsund.

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FAMENNIAN AND MISSISSIPPIAN REEFS AND MOUNDS IN WESTERN EUROPE AND NORTH AFRICA

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Profound changes in the composition and abundance of reefs and mounds took place in the Frasnian, and the reef association of stromatoporid sponges and corals, which had dominated since the Silurian, collapsed gradually.

After the late Frasnian extinctions events wide-spread dominance of siliciclastic facies mostly prevented the development of reefs and mounds in the Famennian of Western Europe. The few Famennian reefs were mostly small and short-lived, except few larger microbial mounds. The peak time for Famennian reef development is the latest Famennian (Strunian), when stromatoporid sponges and subordinately rugose corals formed biostromes along the shelf of southern Laurussia. This Strunian reef association failed to construct build-ups with high relief.

After the collapse of the Strunian reef association in the End-Devonian extinction event, the Mississippian has its own reef history with particular reef associations. Mississippian reefs and mounds were less abundant compared to the Middle Palaeozoic peak, but they are spatially and temporally much more common than previously thought. Although microbial communities often played a crucial role in the formation of build-ups, the Mississippian mounds and reefs cannot be reduced to a post-disaster phase of mud-dominated build-ups.

In Western Europe, reefs and mounds are widely distributed from the late Tournaisian onward, their absence in the early Tournaisian is due to unsuitable facies conditions and the necessary reorganisation after the loss of the main Strunian bioconstructors. The deeper parts of ramp-dominated shelf systems were often occupied by mud-dominated build-ups as seen in the Tournaisian Waulsortian Mounds and the late Viséan mudmounds.

During Viséan times, very different bioconstructors formed reefs in various parts of the rimmed shelf systems. The Belgian Dinantian gives a rare insight into reef formation in marginal marine settings, where microbes and microconchids constructed small reefs. Viséan reefs in middle platform settings were generally small due to the lack of accommodation space. When the latter was available, reefs attained thicknesses of several hundred meters. This is especially true along the edges of late Viséan shelf systems, where a reef association of microbes, sponges, corals, and bryozoans flourished. In England these reefs are named Cracoan build-ups. but they also abundant in Ireland, Belgium, Spain and in North Africa (Morocco and Algeria). The African records are the first reefs described from the African continent since the Frasnian. It is important to note that many late Viséan build-ups previously described as mounds or mud-mounds contain a well-defined framework, and thus represent true reefs. In southern Europe and in Morocco, these late Viséan reefs were cannibalized in the collapse of shelf systems during the Variscan Orogeny, and today are only documented in olistoliths in flysch basins. The youngest Mississippian reefs of Western Europe are earliest Serpukhovian in age and found in southern France. Younger reef formation in the Serpukhovian is only found the cratonal basins of the Sahara. The best examples are from the Béchar Basin, but compared to the Viséan, those reefs are less common, and smaller in sizes.

RECONSTRUCTING SEEPAGE DYNAMICS OF A MIOCENE SYSTEM THROUGH SEDIMENTOLOGICAL AND GEOCHEMICAL CHARACTERIZATION OF AUTHIGENIC CARBONATES AND HOST SEDIMENTS (CORELLA, NORTHERN APENNINES, ITALY)

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New data from facies, stable isotopes (C and O) and CHN analyses on seep-impacted sediments and authigenic carbonates provided insights into dynamics and geochemical background conditions at a Miocene seepage system (Corella outcrops, northern Apennines, Italy).

The examined outcrops comprise 4 lenticular carbonate bodies with maximum length of 200 m and thickness up to 12 m. These carbonates strike parallel to the bedding of the enclosing sediments and show lateral pinch out terminations. Chemosynthetic fauna (mainly Lucinids and Vesycomids) are very common and forms local concentrations of disarticulated or articulated shells; veins and conduits crosscut the carbonate bodies. Microfacies show mottled micrite including clotted textures related to bacterial activity and framboids of pyrite (rosette-like features observed at SEM). $\delta^{13}C$ values of the carbonates (micrites and sparry cement filling veins) range between -42.32‰ to -26.63‰ and are indicative of AOM. The $\delta^{18}O$ range between -5.67‰ to 1.13‰ (average -0.96‰) and is close to the Miocene seawater signature and therefore considered unaffected by significative diagenetic alteration. The host sediments at the top of the carbonates body is depleted in 13C compared to normal marine carbonates and range between -8.40‰ to -4.75‰ and $\delta^{18}O$ is comprised between -3.50‰ and -1.68‰. CHN analyses on the enclosing sediments revealed low TOC values in the range 0.21-0.72% with an average of 0.37%, similar to other Miocene foredeep successions of the northern Apennines. The atomic C/N ratio ranges from 8.93 to 14.05 (avg. 10.84) suggesting minor admixture of land-derived and marine organic carbon.

We suggest, based on field data, geotectonic setting, and geochemical analysis, that a blind fault, rooted in the underlyingTertiary turbidites, acted as a pathway for deep methane-rich fluids. Advective fluid flow resulted in a shallow, near seafloor sulfate-methane transition zone (SMTZ), resulting in the anaerobic oxidation of methane and the precipitation of massive authigenic carbonate. The presence and preservation of chemosynthetic fauna throughout the authigenic carbonate body indicates much of the advective fluid flow breached the seafloor, resulting in methane seepage that helped sustain these chemosynthetic organisms.

MIOCENE SEDIMENTARY INSTABILITIES ASSOCIATED WITH METHANE DERIVED AUTHIGENIC CARBONATES: A NEW CASE STUDY FROM THE NORTHERN APENNINES (PALAZZUOLO OUTCROPS, ITALY)

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Northern Apennines (Italy) host several outcrops of methane derived seep carbonates often associated with sedimentary instabilities such as intraformational slumps, extraformational slides and diapiric processes. Despite the vast body of literature on seep-deposits from the Monferrato to the Umbro-Tuscan sectors of the mountain chain, only a few studies focus on the interplay between paleomethane seepage and sedimentary instabilities because of the lack of good exposures.

In this study we investigate an outcrop located in the Mugello area of the Tuscan Apennines (Prati Piani di Palazzuolo) characterized by the co-occurrence of methane derived authigenic carbonates, chemosynthetic fauna and slump-like structures. The examined outcrop consists of several carbonate blocks with max length of 3.5 m enclosed in a 100 m thick pelitic interval, interpreted as sedimentation above a structural high in the inner foredeep at the front of the Middle Miocene accretionary wedge.

The blocks are mainly located at the base of the pelitic interval and have the same strike as the enclosing sediments. At various levels, pelitic sediments show soft sediment deformation structures (folds, slumps). Within the slumps, we sampled some concretions (silty-carbonate in composition).

The $\delta^{13}C$ value in the carbonates ranges between -18.2‰ and -33.22‰, confirming they are methane derived (AOM-related in origin). Pelites surrounding the carbonate blocks (in situ or transported for a short distance. Isotopic $\delta^{18}O$ values are comprised between -4.31‰ and 0.87‰. The concretions are slightly depleted in ^{13}C (-5.47‰; -10.95‰).

Preliminary data suggest the presence of a seepage system active before the onset of the instability and able to sustain chemosynthetic communities at the seafloor. The interstitial overpressures might have reduced the shear strength of the fine-grained sediments and constituted an important preconditioning factor for diapiric or mass-transport structures. However, this conclusion is still speculative and needs further investigation.

DEPOSITIONAL SETTING AND DIAGENESIS AS KEYS TO RESERVOIR QUALITY: LOWER CRETACEOUS IN THE SOUTHWEST BARENTS SEA

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Porosity and permeability are controlled by the interaction of sediment provenance, depositional processes, and diagenesis. This study attempts to determine and predict which role the depositional environment has in enhancing or decreasing the ultimate reservoir quality in four Lower Cretaceous sandstone reservoirs deposited during a period of rifting in a variety of settings in southwestern Barents Sea. We link the distribution of primary textures, compositions, and diagenetic alterations to depositional sandstone facies. The analytical data include sedimentary core logs, petrographic data, XRD, geochemistry, well logs, and seismic data. The core analysis reveals three main depositional settings for the reservoirs; mass-flow, shallow-marine, and deltaic settings, which we subdivide into 17 sediment facies and 6 facies associations based on grain size, degree of bioturbation, and sedimentary structures among others. Petrographic analysis indicates that the mass-flow sandstone, which is characterized by high energy and high rates of sediment supply, has the highest overall reservoir quality with porosity values ranging between 3 and 19 % (avg. 13%). The high porosity is attributed to a generally good hydraulic sorting, non-pervasive carbonate cementation that inhibited compaction and created porosity through later dissolution, and a moderate mechanical clay infiltration that resulted in clay cutanes on grain rims and further in the precipitation of chlorite, which inhibited quartz growth. Higher porosity in the distal (basin-floor fan) than in the proximal (slope channel) mass-flow facies is considered a result of longer transportation paths and sediment reworking that led to higher compositional maturity of the distal sandstone, whereas abundant sedimentary rock fragments in the proximal facies enhanced mechanical compaction. Deltaic sandstone is characterized by moderate to fluctuating energy and sediment supply and proved ideal conditions for mechanical clay infiltration. Reservoir quality varies (porosities of 2-18 %, avg. 8 %) due to varying amounts of infiltrated clay. Sandstone with moderate clay infiltration proved higher reservoir quality, whereas extensive clay infiltration occluded pore spaces and increased the mechanical compactibility of the sandstone. Lowest reservoir quality (porosities of 1-12 %, avg. 7 %) was observed for the shallow-marine sandstone, which represents an environment of low energy and low rates of sediment supply. Fine-grained laminae and interstitial matrix caused porosity reduction, which was further deteriorated by bioturbation. Abundant mica and feldspar grains in the shallow-marine sandstone, partly a result of the provenance and deep burial, resulted in extensive illitization that further decreased the porosity and permeability.

HOW DO THICK VOLCANIC AND/OR VOLCANICLASTIC PILES OVERLYING PLATFORM CARBONATES INFLUENCE THE DYNAMICS OF CARBONATE-VOLCANOGENIC DIAGENESIS?

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Despite carbonate-volcanic interactions being common in the geological record the diagenetic interactions of such systems are almost unstudied. An outcrop, petrographic and geochemical study details here for the first time the diagenesis of carbonate-volcanogenic units from a Cenozoic, SE Asian carbonate platform overlain by a thick (1-2 km) Miocene volcanogenic pile with associated intrusives. Burial diagenetic effects with fluids of marine precursor origin predominate across shallow-platform, slope and basinal deposits of the syntectonic, block-faulted Tonasa carbonate Platform in Sulawesi. Common, platform-wide late-stage stylolites/dissolution seams are reasonably linked to volcanogenic overburden from the Miocene volcanics of the Camba Formation. Aside from this overburden effect, dynamic diagenetic interactions between the carbonates and volcanogenics are highly localised and mostly limited to less than a few tens of metres either side of conformable formation boundaries or contacts with intrusives. Recrystallised textures and anomalously low negative stable-isotope values ($\delta^{13}C$ and $\delta^{18}O$) within the carbonates in proximity to intrusives are linked to higher temperatures and potential hydrocarbon maturation, perhaps associated with hydrothermal fluids. Where the already lithified, block-faulted upper surface of the shallow-platform carbonates are unconformably overlain, no effects of the volcanogenic pile, different from that on the main platform are discernible on the diagenesis of the limestone. Deep-, and shallow-water carbonates that pass conformably into, or interdigitate with, the volcanogenics show more intense compaction than is seen elsewhere in the Tonasa Formation. More pervasive neomorphic replacement by very coarse bladed to mosaic calcite cements is also localised to shallow-water carbonates conformably overlain by the volcaniclastics. It is inferred that increased pressures and likely higher temperatures associated with emplacement of the volcanogenic pile drove increased chemical compaction as well as localised fluid flow within the shallow-water carbonates driving stabilisation to coarse calcite cements. The volcaniclastics commonly have a fresh appearance, perhaps surprising for the humid equatorial setting of deposition. Possible reasons for this paucity of alteration may include: (i) common lithic and crystal components to the volcaniclastics with a lack of reactive glasses, (ii) common interbedded clay-rich and lava flow units that may act as baffles or barriers to fluid flow, and (iii) potential rapid covering by further volcaniclastics. Alteration of the volcaniclastics includes: sericitisation and some calcitisation of feldspars, some oxidation and Fe-alteration of mafic minerals, common zeolite replacement and growth into pores, and minor late calcite cementation. Alteration of the volcaniclastics is most intense where there are admixed carbonatevolcaniclastics and/or in deeper marine as opposed to terrestrial volcanogenic deposits. There is no evidence for significant exchange of fluids from the pure volcanogenics altering the pure carbonates, and vice versa, rather it appears fluids involved in the alteration of unlithified shallow-water carbonates and volcanogenics were mostly locally and internally sourced. This study is intended to contribute to poorly understood diagenetic variability in carbonate-volcaniclastic systems, and particularly those from the equatorial tropics

NEW EVIDENCE OF BERRIASIAN MARINE INFLUENCE IN THE WEST CAMEROS INTRAPLATE EXTENSIONAL BASIN (NORTH SPAIN)

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The Cameros Basin is the most northwestern basin of the Mesozoic Iberian Rift System. The sedimentary record of the E sector of the basin is organised into eight Depositional Sequences (DS). Each of these DS generally consists of siliciclastic alluvial or sometimes tidal formations, which grade laterally and upwards to shallow, coastal and lacustrine, carbonate formations. Several episodes of marine influence have been described in these DS at the E Cameros Basin, whereas in the W sector only six of those DS are recognized, and the marine-influenced episodes are very scarce (e.g. Río de San Marcos Fm).

Recent sedimentological studies carried out in the W Cameros Basin allow the recognition of new evidence of marine influence during the sedimentation of the DS 3 (Berriasian age) in the lower Salcedal Fm and in the upper Río de San Marcos Fm. These formations show a marked continuity and equivalent sedimentological features between the W Cameros Basin and the small Arlanzón subbasin, located towards the northwest. The purpose of this work is to show the sedimentological and petrographic features of these Berriasian episodes of marine influence in the W Cameros Basin, including the Arlanzón sub-basin.

The Río del Salcedal Fm (0 to 69 m thick) corresponds mainly to a meandering fluvial system consisting of lenticular bodies of sandstone, and silty and sandy mudstone. Locally, its uppermost part corresponds to a siliciclastic tidal flat mainly consisting of alternating sheets of flaser-bedded sandstone and silty mudstone with some associated channelized trough cross-bedded sandstone, occasionally displaying very thin mud laminae between the sandstone foreset laminae.

The Río de San Marcos Fm (0 to 84 m thick) was deposited in a complex mosaic-framework of facies and environments which can be classified as a "carbonate coastal wetland system". It consists mainly of well-bedded, often silty limestone (mainly mudstone and wackestone) alternating with marl. The coastal wetland was constituted by different shallow water bodies, of either fresh or brackish water, depending on the seawater input. Freshwater bodies were characterized by the presence of ostracods, charophytes and fish remains, and presented evidence of subaerial exposure (paleosols or desiccation cracks). The brackish water bodies presented different facies associations: the northern water bodies contained benthic foraminifers (mainly miliolids), ostracods and fish remains, and were affected by periodic subaerial exposure manifested by desiccation cracks. The southern ones were characterized by monospecific dasycladals, ostracods, charophytes, gastropods, and bivalves, with paleosol development. The development of dasycladal meadows is interpreted as related to lower water turbidity in comparison to the northern water bodies. The paleogeography of this carbonate coastal wetland and the Río del Sacedal tidal flat indicates that the marine influence would have reached this basin from the north in stages of connection with the Basque-Cantabrian Basin.

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EARLY AND LATE SURFICIAL KAOLINITE CEMENTS: CONSTRAINS IN A PALEO PETROLEUM SYSTEM, CAMEROS BASIN, SPAIN

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Several types of kaolinite textures appearing in Cretaceous sandstones from the intracratonic Cameros Basin (Spain) permit to outline the unconformity between syn-and post-tectonic units.

The Cameros Basin is an inverted extensional basin (North-Central Spain) infilled from Tithonian to Early Albian times. During its evolution, a petroleum system was developed in the southern area of the basin. The reservoir of the system is the post-extensional Utrillas Fm. (Middle Albian), where common bitumen accumulations (tar sands) are found. The source rock of this paleo-petroleum system is still controversial. Abundant bitumen residues have been found in the last basin infill clastic units (Valanginian – Early Aptian, Abejar Fm.), which have been considered as oil-carrier beds.

The Abejar Fm. is composed of arkosic sandstones with a diagenetic history consisting of mechanical and chemical compaction, kaolinite pore-filling and epimatrix derived from K-feldspars alteration, quartz overgrowth, and secondary porosity generation by feldspar dissolution. The porosity is primary and secondary in origin. Kaolinite pore-filling appears as the latest diagenetic process affecting sandstones during telodiagenetic stage (basin uplift). This last cement occurs as pale to dark orange in color with a texture of clay coats covering primary and secondary pore walls, growing over quartz cement crystal faces. Textures denote that this cement grew in a vadose environment, containing abundant ghosts of bacteria and fungi. These kaolinite "cutans" appear to be locally impregnated in bitumen, suggesting the role as oil pathway of the syn-extensional sandstones during oil migration.

The reservoir of the paleo-petroleum system (Utrillas Fm.) is constituted by sandstone channels interbedded with shales. Locally, porosity in the Middle Albian sandstones is almost totally occluded by homogeneous bitumen pore fillings. In these deposits, quartz cement was not developed, indicating that bitumen accumulation occurred in an early diagenetic stage. Sandstone diagenesis reveals early kaolinite cements with several textures occluding primary pores. A first stage of cementation occurs as grain coats with the development of orange kaolinite laminae with meniscus textures, suggesting a vadose origin in an eodiagenetic environment. These textures are very similar to the late kaolinite cement in the Abejar Fm. sandstones. In addition, a second kaolinite pore-filling with typical palette aggregates occluded remnant primary pores. Finally, calcite cement replaces kaolinite as a late diagenetic process in the Utrillas Fm.

Such a variety of kaolinite textures in the Abejar and Utrillas Fms. demonstrates differences in the timing of kaolinite precipitation (telodiagenetic and eodiagenetic, respectively), outlining the unconformity between syn-and post-extensional stages in the Cameros Basin.

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SEDIMENTARY RECORDS OF PALEO GROUNDWATER IN THE ARID EAST AFRICAN RIFT SYSTEM RESULT FROM THE INTERPLAY OF HYDROLOGY, BIOLOGY AND GEOLOGY

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The East African Rift System (EARS) is a > 2000 km long feature of late Cenozoic age composed of a series of basins that are being infilled with lava flows and reworked volcaniclastics. Rift basins are shallow, hydrologically closed systems that are responsive to changes in regional hydrology and are particularly sensitive to changes in the hydrologic budget (Precipitation, PEvapo-Transpiration, ET). The hydrologic budget varies, here, with long term Milankovitch precession cycles (19-23 ka) i.e. astronomically controlled, wet-dry cycles. P varies with changes in solar insolation which fluctuates ~10 % over a cycle. Stronger insolation drives stronger summer monsoon maxima increasing P. Mean annual temperature (~27°C) and ET (~ 2500 mm/yr) do not vary much; the hydrology effects dominate. Groundwater is shielded against evaporation and can persist, after the recharge that occurs during wet parts of the cycle, well into the dry parts of the cycle. Recent hydrogeological modeling indicates that groundwater supplies in EARS may persist for up to ten thousand years.

Very little is known about the paleo groundwater system in the rift, as most paleoenvironmental studies of EARS have focused on paleo lake records as a means determining geologic history and of tracking climate fluctuations. Records of groundwater are subtle; evaporating water may not leave any mineral record at all. But, groundwater discharge sites with discharges of 1,000 m^3/yr are robust enough to maintain a high water table, produce wetlands that support growth of phreatophytes and lead to high organic carbon productivity. Biology is, therefore, critical for creating a record of paleo groundwater. Wetlands are composed of organic-rich clay deposits that contain eolian-transported mineral matter, plant remains (e.g. roots, stems), pollen, phytoliths, diatoms, root casts, charcoal, carbonate and manganese-rich nodules, as well as copious evidence of bioturbation (ranging from plants and trace-making burrowing organisms to invertebrates to large vertebrate trampling). After lithification, paleo wetlands preserve little original organic matter volumetrically, but do retain organic carbon biomarkers (n-alkanes) and phytoliths, diatoms and pollen. Plant remains are commonly silicified because aqueous CO_2 levels are often elevated due to high rates of microbial respiration that lowers pH, buffering the system. The thermodynamic stabilities of carbonates, silicate and sulfide mineral systems vary as a consequence and produce localized mineral assemblages, geochemical and stable isotope signatures.

Geology is the third critical factor as it dictates the spatial location of springs and seeps, e.g. perched water on top of impermeable beds, at the base of slope, or in faults zones that act as conduits to the surface. Whereas, water and biology creates the groundwater record, the geology affects the groundwater discharge rate under a given hydraulic head. In addition, weathering of the volcanics supplies the calcium for freshwater carbonates precipitates such as tufa and travertine. In summary, groundwater records are the product of rift hydrology and geology and associated biology and document long term evolution of climate-sensitive environments.

THE LOWER SERIE RESERVOIR OF SANDY SHALE TRIASSIC IN BEN-KAHLA AREA; OUED MYA BASIN- ALGERIA

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The Benkahla field is located in the area, formerly called Garackrima at about 80 kilometers to the west of Hassi Messaoud, at the same distance (20 km) to south of Guellala field and to the east of Haoud Berkaoui one. Its area is about 83.5 km^2. It is positioned between the two giant Saharan fields of Hassi Messaoud and Hassi-R'mel and at 600 km south of the Algerian capital.

From a structural point of view, the region's field lies on a narrow trend running north-east-south-west, measuring a few tens of kilometers.

This trend consists of a succession of dislevelments organized in several anticlinal and synclinal folds. This is derived from the seismic profiles analysis where low slip faults have been interpreted. The nature of the reservoirs, point bars encountered in the Lower Serie of the Sandy-Shale Triassic, explains the complexity of the Benkahla region from this point of view. Indeed, the lateral lithology changes of sandstone / shale are frequent and realized over short distances (1.5 to 2km).

Thanks to the faciologic analyzes of the studied wells, it emerges from the sedimentological point of view that the Lower Serie is a shaly-sandstone continental set which lies in inconformity on the Paleozoic. Its very pronounced thickness variation reflects the filling of an irregular erosion surface by a characteristic fluvial system. In addition, a paleo-environmental evolution takes place by a proximal zone towards the south (fan deposits) and a more distal zone represented by a fluvial braided system towards the north. Between the sandstone deposit bars, the shaly beds indicate the presence of flood plains.

The well-defined oil character in this region is supported by good reservoirs discovered which lead to the development of the Benkahla field.

UNUSUAL STRUCTURAL DIVERSITY OF MAT-RELATED STRUCTURES AND THEIR IMPLICATIONS FOR THE FRANCEVILLIAN BIOTA (FB2 FORMATION, 2.1 GA, GABON)

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Microbial structures are ubiquitous in the fossil record for 3.7 billion years, but they have been inadequately described in studies of Paleoproterozoic rocks. The Francevillian Series (2.2 – 2.0 Ga, Gabon) has been intensively studied because of economic interests due to uranium or manganese ore deposits but also due to the large colonial macroorganisms of various sizes and shapes. More than ten representative types of exceptionally preserved mat-related structures comprising elephant-skin textures, putative macro-tufted microbial mats, domal buildups, flat pyritized structures, discoidal microbial colonies, horizontal mat growth patterns, wrinkle structures, kinneyia structures, linear pattern sand nodule-like structures were observed in a 20 m thick interval of both sandstone (FB2a) and black-shale facies (FB2b). The establishment of such mat-related structures is consistent with a low to moderate hydraulic pattern and a low sedimentation rate. By using thin-section petrographic analyses and SEM observations, microtextures of bacterial mats mainly encompass floating silt-sized quartz grains, concentrated heavy minerals, wavy-crinkly laminae and pyritized structures. The mineralogical composition of clays shows striking differences between mat-layers and the surrounding sediments. Besides, their biological origin has been examined through Raman spectroscopy and organic elemental analyses of carbon-rich laminae. Comparisons with modern analogues and a $\delta^{13}C$ signature for the organic matter ranging from -41.26‰ to -30.67‰ show that the palaeoenvironment was typical of the euphotic zone colonized by benthic photoautotrophic organisms. Some macrofossils and microbial mats occur relatively close. This suggests that macroorganisms may have fed on microbial mats, or that microbial communities may have acted as benthic O_2 oases linked to cyanobacterial mats. Alternatively, this association may point to improve the preservation of the oldest large colonial organisms related to the presence of the microbial communities, as bacterial mats are known to strongly biostabilize the substrate.

ZIRCON SIZE-AGE SORTING AND SOURCE-AREA EFFECT: THE GERMAN TRIASSIC BUNTSANDSTEIN GROUP

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Taking sedimentary sorting effects into account, we present a detrital-zircon provenance study for continental deposits of the Central European, Early Triassic Buntsandstein Group in Germany. The Buntsandstein Group was deposited in an extended intracontinental sag basin of Pangea under arid climate conditions. It included several intrabasinal tectonic swells, some of which have been assumed topographic highs acting as detrital source areas. This study of the Lower and Middle Buntsandstein in Central Germany indicates that particularly the Massif Central and the Bohemian Massif contributed to the basin fill of the central part of the Central European Basin. The Rhenish Massif, an assumed highland, was submerged. This interpretation is based on totally > 1000 zircon grains < 250 µm long from 12 sandstone beds. The unbroken grains in seven of the beds have mean lengths of 190-220 µm and five are composed 100-140 µm long grains in average. All zircon separates have a dominance of 340-320 Ma (Carboniferous) ages, representative of granitic, probably zircon-rich, rocks from the Variscan Orogen of the Massif Central and the Bohemian Massif. This first-cycle detritus was mixed with recycled, abraded zircon grains from Ediacaran to Palaeozoic metasedimentary units feeding the basin with 610-460 Ma (Ediacaran to Ordovician), ca. 1 Ga and 2 Ga age grains, which is typical for Gondwana-derived material. The Ediacaran to Ordovician age population is common only in five samples with mean grain lengths of 100-140 µm, whereby grains of such ages mainly are <130 µm in the 7 most eastern sampled sandstone beds (eastern group) but equally common in all grain sizes in the four most western sandstone beds (western group). The western group was fed from the Massif Central and the eastern group derived from the Bohemian Massif. However, abrasion, age-population variations for pre-Variscan grains, and dominating wind directions indicate that two different fluvial systems delivered the Bohemian material and that this was combined with aeolian and alongshore lacustrine transport from the south and west. We conclude that interpretation of detrital zircon ages preferably should be made separately for different size classes, because zircon studies performed on broad grain-size intervals without considering possible size-age correlations may disguise sorting effects that potentially can lead to a deviating source-area interpretation.

AN ANDROID MOBILE APPLICATION FOR THE PARTICLE SHAPE DETERMINATION OF COARSE SEDIMENTS IN THE FIELD

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Grain size analysis and particle shape of sediments and soils are important parameters for the sedimentological as well as for engineering studies. Shape classification of sedimentary particles is based on visual or ocular determination of roundness, comparing the shape of grains to prototype charts. There are several methods in the literature for particle shape classifications using 2D-image analysis but there is a lack for rapid and precisely determination and description in the field. In our study we present a 2D-image software for mobile devices (cell or tablets) which has been adapted to calculate the grain size, classify particle shape and geometrical shape indicators rapidly in the field. The application has been created for the Android mobile operating system under Eclipse platform. It is easy to use and exploits many features of the modern mobile devices. The user can edit a photo taken in the field in real time. One of the most critical aspects of the process is the background removal of the photo. Therefore, image processing algorithms are supported for this purpose. Additional tools such as blocking a useful area and marking an area to be deleted, removes the defects that comes out of the lighting while taking the photo. Finally, the tracing of image and the calculation of particle shapes are performed. Our software was validated and tested with idealized geometries, natural grains and an evaluation/comparison with other methods was made.

CARBONATE RESERVOIRS FROM THE JURASSIC OF PORTUGAL: OUTCROP ANALOGUES WITH A WINDOW INTO PORE-SCALE

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The Jurassic of the Lusitanian Basin (LB), Portugal, shows a range of carbonate facies representing ramp and other platform depositional systems, many of which offer valuable insights into multiscale carbonate reservoir analysis, providing varied types for potential analogues for characterization and modelling, crucial in reducing subsurface uncertainty. The main focus here is on Middle Jurassic (MJ) inner to mid ramp successions, that are the most suitable and thoroughly studied from a reservoir perspective. However, other examples are noteworthy, namely MJ outer ramp debris-flows, Lower and Upper Jurassic microbialites, coquinas, limestones with oil/bitumen-rich fractures and stylolites/dissolution seams.

The thick shallow-water MJ successions extensively crop out, either in natural outcrops or in quarries, exhibiting several lithofacies, namely: fossiliferous/bioturbated peloidal mudstones to packstones; oolite-and skeletal-dominated grainstones and rudstones (sandbodies); coral-algal boundstones and biostromes; lagoonal and peritidal deposits. Corals, algae, molluscs, echinoderms, benthic foraminifera and other fossil groups are common. The sandbodies commonly compose thick superimposed multistorey units, may display cyclical or non-cyclical patterns and exhibit lateral and vertical variations in allochem distribution, cross-stratification types and scales and other structures. Tempestites, shell lags, erosional palaeosurfaces, hardgrounds, interfingering layers of different textural types are usual; locally, syn-sedimentary faults and fluid-escape features occur. Besides later fracturing, stylolites and other compactional features occur but are not widespread, due to early/multi-generation cementation. Many porosity and permeability anisotropies derive from this sedimentary heterogeneity, as typical of carbonate reservoirs, offering examples to be examined at outcrop, further complemented by microscale data. Though most of the sandbody and biostrome facies correspond to tight-low porosity (< 4%) reservoirs, there are also units with moderate (5-10%) and high (12-16%), locally even excellent (> 20%) porosities, and low to high ranges within a same unit. Pores are usually poorly connected, with a few exceptions (e.g. due to enlarged vuggy network, channels along stylolites, fracturing). The multi-phase (early, burial and telodiagenetic) dissolution is sometimes associated with dolomitization/dedolomitization.

The innermost lower-energy facies are mostly composed of fossiliferous oncoidal-peloidal wackestones / packstones, fenestral and microbially laminated mudstones, some dolomitic. Mid ramp, more open-marine influenced deposits are fossiliferous micritic, locally slightly argillaceous limestones. Locally, late tectonic and decompression on originally tight micritic limestones led to somewhat improved permeability, providing examples of fractured-enhanced reservoirs. At places, intervals were particularly affected by dolomitization/dedolomitization, impacting both grain-supported and micritic lithofacies. Porosity is observed at different scales, namely vuggy, mouldic, intraparticle, channel, intercrystalline and fracture. However, massive tight zones also occur at the same outcrops. Fracturing, faulting and later karstification further contribute to complex porosity-permeability patterns.

Therefore, these LB successions are highly instructive on how depositional fabrics and structures may influence and may be differently impacted by diagenesis (processes, paragenesis), providing study examples for several types of carbonate reservoirs. The field to pore-scale knowledge on the petrophysical properties, facies, diagenesis, geometry and relationship with depositional environments of these successions allows understanding reservoir types, stratigraphic and diagenetic traps, seals and overall lateral and vertical variability, that can positively impact the strategic approach for carbonate reservoir exploration and development.

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FIRST DIRECT MEASUREMENTS OF SECONDARY FLOW IN OCEANIC TURBIDITY CURRENTS SUGGEST NEW VIEW OF DENSITY FLOW STRUCTURE

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Turbidity currents form the largest sediment accumulations on the planet. These flows can travel for thousands of kilometres along meandering channel systems, carrying the majority of their sediment in suspension. The interaction of these flows with bends in the channel systems is important to keep sediment in suspension. In channel bends, flows show a helical structure that is a combination of a downstream flow (primary flow) and a cross-stream flow (secondary flow). The secondary flow displaces sediment sideways across the channel, builds and erodes deposits, and ultimately controls the evolution of the channel system. Secondary flow has been extensively studied in fluvial systems. There, it comprises a single flow-cell that moves towards the inner bend at depths close to the bed. In contrast, secondary circulation is poorly documented in full-scale turbidity currents, because of difficulties in collecting direct field measurements. Early studies of secondary flow in turbidity currents were based on experimental and numerical models, and they proposed both river-like and river-reversed senses of secondary flow. Later, direct observations of secondary circulation in saline density flows suggested that the direction of secondary flow depends on density stratification. Despite these cumulative advances, the sense of secondary flow in turbidity currents has not been directly measured in full scale sediment-laden flows. Here we present the first measurements of secondary circulation in oceanic turbidity currents, which occurred within the deep-sea Congo Canyon. The measurements show a consistent river-reversed pattern downstream of the bend apex. We build on these results to develop a new integrated model for secondary flow in a wider range of flows. Our conclusions have implications for understanding depositional patterns of flows and for the evolution of channel systems.

PLIO-PLEISTOCENE TIDAL RIDGES COMPLEXES IN SOUTH CHINA SEA (NW INDONESIA) REVEALED BY 3D SEISMIC

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The Sunda shelf partly including South China Sea forms one of the larger epireic sea. It is well known for the development of tidal sandbodies at the present, and also in the Miocene.

Using a high quality 3D survey in the North Sokang area located offshore NW of Indonesia; we can establish that tidal hydrodynamism also occurs in this area from Lower Pliocene to the present. This is revealed by the systematic occurrence of elongated sand bodies which are best interpreted as elongated shelf tidal ridges.

These sandbodies occur in most of depositional sequences from 5.9 Ma to the Quaternary and are definitively not restricted to transgressive system tracts as commonly assume; but they seem to be present in almost all layers (i.e. LST-TST & HST). They are organized in parallel belts; individual ridge shows a range of size of 2.5 to 10 km in width and up to 40 km in length. According to well data individual upward coarsening sequence thicknesses varied from 20 m to 50 m. These dimensions are in general agreement with existing published data base, however because of the limited size of the 3D cube some sand bodies could be even longer to reach (≥100 km); a similar size of well documented southern North Sea analogs. Internal architecture cannot be directly assessed as in shallow setting because of limited seismic resolution, but lithologies can be approach by the way of amplitudes which are calibrated by two exploration wells and demonstrate that ridges have a sand rich core grading to finer grained sediments in ridge margins with a gradual change. Amplitude responses being exemplified by CO_2 accumulation within the sandy part of the ridges.

In conclusion, tidal currents precise directions are difficult to determine because currents can be SW-NE or vice versa as deduced from the ridge geometry. However modern day currents have the same direction and are seasonally alternating. This suggests perennial tidal hydrodynamism conditions since Upper Miocene up to the present which is quite interesting.

EARLY DIAGENETIC ORIGIN OF RED PELAGIC CARBONATES AS AN INTERPLAY OF GLOBAL CLIMATE AND LOCAL BASIN FACTORS: INSIGHT FROM THE LOWER DEVONIAN OF THE PRAGUE BASIN, CZECH REPUBLIC

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Red pelagic sediments are relatively common in the Phanerozoic. They are often interpreted as products of sea-bottom oxidation during greenhouse climate showing a conspicuous alternation with black shales and thus carrying important palaeoceanographic information. The Lower Devonian (Pragian) carbonate strata of the Prague Basin, Czech Republic (Praha Formation) contain a marked band of red pelagic carbonate, up to ~15 m thick, which can be correlated for several tens of km. We investigated seven sections (17 to 255 m thick) of the Prague Basin using the methods of facies analysis, outcrop gamma-ray logging, diffuse reflectance spectroscopy, optical microscopy, element geochemistry, magneto-mineralogy and electron microprobe analysis. The aim was to find the mineral carriers of the red colour, investigate the stratigraphic context of the red carbonates and evaluate the local and global prerequisites for their formation. The red pigmentation represents enrichment by hematite with respect to goethite. Approximately 31% of the total reflectance falling in the red colour band represents a threshold for red coloration. The red pigmentation is carried by submicronic hematite dispersed in argillaceous pelagic calcilutite and/or inside skeletal allochems. Gamma-ray log correlation indicates that the red carbonate band developed in stratigraphic levels with low sedimentation rates, typically from ~1 to ~7.1 mm/kyr, which are comparable to the Mesozoic Rosso Ammonitico facies. The red beds and the whole Praha Formation (Pragian to early Emsian) are characterized by low TOC values (< 0.05%) and low U/Th, Mo/Al, V/Al, Zn/Al, Cu/Al and P/Al ratios indicating oligotrophic, highly oxic sea-bottom conditions. This period was characterized by global cooling, a drop in silicate weathering rates and in atmospheric pCO_2 levels. The lower Devonian successions of the Prague Basin indicate that switching between two potentially global climatic modes, cold oligotropic and warm mesotrophic, may have been responsible for the alternation of red and grey carbonate strata, respectively.

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SEDIMENT BUDGET AND STRATIGRAPHY OF DAM RESERVOIRS AS ANTHROPOGENIC BARRIERS IN RIVER SYSTEMS: CASE STUDIES FROM SMALL-SCALE RIVER CATCHMENTS, CZECH REPUBLIC

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Dam reservoirs are barriers of sedimentand pollutant transport along river courses, which strongly affect river sedimentary budgets and anthropogenic pollutant fates. At the same time, reservoir depositional systems have complex shape and internal structure. We investigate the interplay between sediment architecture, bottom morphology, and geochemistry of lithogenic and anthropogenic compounds in sediments of nine reservoirs located on three Czech rivers, the Labe, Chrudimka and Ohře River. Built between 1916 and 1972, these reservoirs cover a time slice of frantic dam building and peak industrial pollution in the Central Europe. Our multifaceted study includes sonar bathymetry mapping, 2D ground penetrating radar imaging, evaluation of historical maps using GIS applications, stratigraphy of sediment cores, ^{137}Cs dating, grainssize analysis, organic and inorganic geochemistry of core sediments. The aims are to quantify the reservoir sediment budgets, make an insight into consequences of damming on fluvial erosion/sedimentation styles downstream of dams, and assess its effect on dispersal of anthropogenic pollutants. The budget and architecture of fine-grained dam-reservoir deposits are strongly influenced by the catchment bedrock geology (crystalline vs. sedimentary rocks) and the reservoir shape. The reservoirs show a strong tendency towards infilling of former river thalwegs by fine-grained deposits distributed via hyperpycnal flows, as well as a tendency towards development of deltaic systems at the river inflow. Considering the historical record of reservoir discharge and repeated lake-level falls, the reservoir depositional systems represent natural labs of siliciclastic sequence stratigraphy.

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SEA-LEVEL CHANGES VS. CARBONATE PRODUCTIVITY AS CONTROLS ON EARLY AND MIDDLE DEVONIAN BIOEVENTS: FACIES- AND GAMMA-RAY BASED SEQUENCE-STRATIGRAPHIC CORRELATION OF THE PRAGUE BASIN, CZECH REPUBLIC

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The Devonian marine stratigraphic record is characterized by a multitude of bioevents – overturns in pelagic and benthic faunal assemblages, which are associated with distinct changes in lithology. The coincidence of lithologic and biotic changes can be explained by the causal link between biotic evolution, carbonate production and relative sea-level changes. To gain insight into the sea-level history of Early and Middle Devonian bioevents (the Lochkovian/Pragian Event, Basal Zlíchovian Event, Daleje Event, and Choteč Event) we carried out a sequence-stratigraphic analysis of carbonate-dominated successions of the Prague Basin (peri-Gondwana), the classical area of Devonian biovents. The study is based on basin wide correlation of facies and field gamma-ray spectrometry (GRS) logs from 18 sections (Lochkovian to Eifelian), supported by element geochemistry and published biostratigraphic and carbon isotope data. The Devonian carbonate deposition of the Prague Basin alternated between two end-member modes, oligotrophic homoclinal ramp (Praha and Daleje-Třebotov formations) and mesotrophic distally steepened ramp (Lochkov, Zlíchov, and Choteč Formations). They show contrasting facies (particularly the absence/presence of gravity-flow deposits), allochem composition, U/Th ratios, and geochemical composition (productivity proxies such as P/Al, Si/Al, Zn/Al, TOC and stable carbon isotopes). The mesotrophic systems reflected increased availability of nutrients on the shelf during the late Lochkovian, early Emsian (Zlíchovian), and Eifelian periods of higher sea surface temperature, pCO_2, and silicate weathering rates. The oligotrophic systems deposited during the

Pragianearliest Emsian and late Emsian (Dalejan) periods reflected reverse paleoclimatic trends. We identified three depositional sequences (DS), DS1 (base of Pragian to early Emsian); DS2 (early Emsian to mid Emsian); and DS3 (mid Emsian to mid Eifelian) and integrated them into a peri-Gondwanan relative sea-level curve, which is confronted with the Euramerican sea-level curve of Johnson et al. (1985). The bioevents coincided with several sequence-stratigraphic surfaces representing variable limbs of the relative sealevel curve. On the other hand, their conspicuous coincidence with the switching intervals between the colder oligotrophic and warmer mesotrophic modes suggests that organic production linked to global climate was the primary control on biotic overturns while sea-level fluctuations played a subordinate role.

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RADIOLARIAN RESPONSES TO PALEOCEANOGRAPHIC REGIME IN THE PIENINY KLIPPEN BELT BASIN OF NORTHERN WESTERN TETHYS DURING THE LATE JURASSIC

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Radiolarian frequency and composition were determined for the Upper Jurassic radiolarite sequence and the uppermost part of Ammonitico Rosso-type limestone (Czajakowa Radiolarite Formation and Czorsztyn Limestone Formation, respectively) from the Pieniny Klippen Belt (PKB), a part of the Carpathians. The sediments of the PKB have been deposited in the Pieniny Basin, a part of the Penninic Ocean on a northern sector of the Alpine Tethys.

Three groups of radiolarian habitat species characteristic for water masses as surface, subsurface and intermediate were defined. The sedimentation of the radiolarite succession lasted approximately 8.0 Ma, spanning time from the middle Oxfordian up to the lower Kimmeridgian. The radiolarian diversity and specimens richness is high in the lower part of the radiolarite sequence and suddenly dropped in its middle part. Period of highest radiolarian accumulation lasting ca. 5.0 Ma was recorded in the lower part of the succession comprises uppermost part of the red Ammonitico Rosso-type deposits overlaying by red and green radiolarite sequence. It was characterized by domination of subsurface radiolarian group indicated on prevailing of upwelling conditions. Higher abundance of surface species occurred in the upper part of the lower Ammonitico Rosso-type deposits and green and red radiolarite in the upper part of the sequence indicates on wide distribution of warm surface waters. These results indicate that radiolarian distribution in the Pieniny Klippen Basin was controlled by sea-surface temperature induced by ocean circulation with of primarily importance.

Fluctuations in abundance of radiolarian species assembled in surface, subsurface and intermediate groups in the Pieniny Klippen Basin might be related to changes in sea surface temperatures and nutrient supply caused by successive periods of enhancement and weakening of upwelling induced by monsoon circulation. The increasing of surface and intermediate radiolarian species before 159.3 Ma and after 154 Ma might indicate higher surface-water temperature presumably coinciding with deepening of thermocline, and weakening of upwelling. Radiolarian species which prevail in the assemblage might by algal symbiont-bearing forms living in the surface water. Most species of the former group have skeletons predictable to hosted algal symbionts, like species of the genera *Homoeoparonaella*, *Tritrabs*, *Tetratrabs* and *Acanthocircus*. The increasing subsurface dwellers at period between 159.3 and 154 Ma might indicates higher productivity in subsurface and surface waters due to shallowing thermocline, where colder water rises from intermediate depths caused lowering of SST and gave possibility subsurface species to proliferate.

SOURCE-TO-SINK CONSTRAINTS ON TECTONIC AND SEDIMENTARY EVOLUTION OF THE CENTRAL RANGE, CENDERAWASIH BAY (INDONESIA) AND GULF OF PAPUA (PAPUA NEW GUINEA)

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The island of Papua New Guinea is the result of continent-arc collision that began building the island's Central Range during the late Miocene. Recent studies have shown that rapid subduction, uplift and exhumation events took place in response to a fast-oblique convergence between the Pacific and the Australian plates. The tectono-sedimentary evolution of the Cenderawasih Bay, in the northwestern part of the island of Papua New Guinea (Indonesia), which links the Kepala Burung block to the Central Range is still poorly understood. Previous studies have shown that this bay contains a thick (> 8 km) sequence of undated sediments. One hypothesis claims that the embayment resulted from a 3 Ma aperture created by anticlockwise rotation of the Kepala Burung block with respect to the northern rim of the Australian plate. Alternatively, the current configuration of Cenderawasih Bay could have resulted from the southwest drift of a slice of volcanics/oceanic crust between 8 and 6 Ma. Using a source-to-Sink approach, based on i) a geomorphologic analysis of the drainage network dynamics, ii) a reassessment of available thermochronological data, and iii) seismic lines interpretation, we suggest that sediments started to accumulate in the Cenderawasih Bay and onshore in the Waipoga Basin in the late Miocene since the beginning of the Central Range building at 12 Ma, resulting in sediment accumulation of up to 12200 m. Hence, volume balance supports the view that the embayment did not occurred in response to a hypothetical recent (2-3 Ma) aperture of the Bay. At first order, we predict that infilling is mainly composed of siliciclastics sourced in the graphite-bearing Ruffaer Metamorphic Belt and its equivalent in the Weyland Overthrust. Ophiolites, volcanic arc rocks and diorites contribute minor proportions. From the unroofing paths in the Central Range we deduce two rates of solid phase accumulation (SPAR) since 12 Ma, the first one at a mean SPAR ranging between 0.12-0.25 mm/yr with a maximum SPAR of 0.23-0.58 mm/yr, and the second during the last 3 Ma, at a mean SPAR ranging between 0.93-1.62 mm/yr and with a maximum SPAR between 2.13-3.17 mm/yr, i.e., 6700-10000 m of Plio-Pleistocene sediment accumulation. Local transtensional tectonics may explain these unusually high rates of sedimentation in an overall sinistral oblique convergence setting. We further extended this approach to the Gulf of Papua (Papua New Guinea), a foreland basin developed in the passive margin of the Coral Sea and fed by the Papuan fold-and-thrust belt and Aure fold-and-thrust belt. We compare these two source-toSink systems to highlight the tectonic control on sedimentary flux, provenance and SPAR in the Cenderawasih Bay and Gulf of Papua.

HOLOCENE TURBIDITE PALEOSEISMOLOGY ALONG THE ALGERIAN MARGIN: A SYNTHESIS

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Northern Algeria is threatened by moderate to large magnitude earthquakes resulting from the slow convergence between the African and European plates. Main active faults are located along the Algerian coast, mainly onshore in the western margin and also offshore in the central and eastern margins. As shown by the 2003 Mw 6.8 Boumerdès earthquake, the largest seismic events are able to trigger numerous and widespread turbidity currents flowing over ~150 km along strike in the Algerian basin and reaching 2800 m of water depth, as attested by submarine cable breaks.

Sedimentological and stratigraphic studies of sedimentary cores collected at the base of the continental slope and in the Algerian basin show successions of turbidite deposits interstratified with hemipelagic sediments over the Holocene. Using robust age models based on radiocarbon measurements on planktonic foraminifera, we find that most turbidites from the deep basin can be reliably correlated over long distances (> 50-100 km along the margin): they indicate synchronous and multisource turbidity currents, which is likely the record of large earthquakes earthquakes at least during the past 9 kyr.

Three margin segments were investigated: the western margin (Kramis area), the central margin (Algiers area), and the eastern margin (Djijel area). Studies of the western and the central margins are based on data made of several well-correlated cores and robust stratigraphic models. They show differences in the number of events and in recurrence intervals (13 events within 8 kyr in the Kramis area against 36 events within 9 kyr in the Algiers area). However, both studies display similarities in time distribution (i.e. clusters of events separated by quiescence periods), supporting the same bimodal cyclicity of large ruptures. We suggest that the proximity of large seismogenic faults below the continental slope in the Algiers area explains why turbiditic events are more numerous than those occurring in the Kramis area. In the eastern margin (Djijell area), the number of core is limited and the first study, based on only two cores located in the deep basin, has evidenced 27 turbidites in the last 9 kyr.

A synthesis of the paleoseismological studies based on the Holocene turbidite sedimentary record is proposed at the scale of the margin. We focus the discussion on the possible synchroneity of large events between the three segments and the implications of our findings on earthquake triggering processes at the time scale of the Holocene.

POST-RIFT VERTICAL MOVEMENTS OF THE SOUTHERN AFRICAN MARGINS-IMPLICATIONS FOR THE SOUTH AFRICAN PLATEAU UPLIFT

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The South African (Kalahari) Plateau is the world's largest non-orogenic plateau. It forms a largescale topographic anomaly (×1000 km) which rises from sea level to > 1000 m. Most mechanisms proposed to explain its elevation gain imply mantle processes. The age of the uplift and the different steps of relief growth are still debated. On one hand, a Late Cretaceous uplift is supported both by thermochronological studies and sedimentary flux quantifications. On the other hand, geomorphological studies suggest a Late Cenozoic uplift scenario.

Onshore, on the mapping and chronology of all the macroforms (weathering surfaces and associated alterites, pediments and pediplains, incised rivers, wave-cut platforms) dated by intersection with the few preserved sediments and the volcanics (mainly kimberlites pipes).

Offshore, on a more classical dataset of seismic lines and petroleum wells, coupled with biostratigraphic revaluations (characterization and dating of vertical movements of the marginssediment volume measurement).

The main result of this study is that the South African Plateau is an old Upper Cretaceous relief (90-70 Ma) reactivated during Oligocene (30-15 Ma) times. Its evolution can be summarized as follows:

• 100-70 Ma (Cenomanian to Campanian): low elevation plateau (0-500 m) with older and higher reliefs located along the Indian side, acting as a main divide between the Atlantic and the Indian Oceans. First uplift occurred in the east at ~92 Ma, with a fast flexuration of the Indian margins. This initiates a paroxysm of the erosion (90-80 Ma) with the growth of a large delta along the Atlantic margin (Orange delta). Deformation migrated progressively westward and resulted on the growth of the Atlantic marginal bulge between 81 and 70 Ma. Most of the present-day relief was probably created at this time. This is supported by the decrease of the sedimentary flux which suggests a reorganisation of the interior drainage pattern.

• 70-30 Ma (Uppermost Cretaceous-Paleogene): most of the relief is fossilized and weathered relative tectonic quiescence.

• 30-15 Ma (Oligocene-Early Miocene): second period of the South African Plateau uplift. Most of the deformation took place along the Indian side of the Plateau (strike flexure) feeding the Zambezi, Limpopo and Tugela deltas.

• Since at least Middle Miocene times, all those reliefs have been fossilized, with very low erosion rates (x1m/Ma), in response to the major aridification of southern Africa.

INVENTORY OF THE FRENCH SALT FORMATIONS FOR ENERGY STORAGE IN SALT CAVITIES (FLUIDSTORY ANR PROJECT)

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The major hurdle of energy transition in France is the energy storage, since the renewable sources with great potential (wind and solar) are highly intermittent. The FLUIDSTORY project, funded by ANR explores the innovative concept consisting in storing energy trough fluids vectors (O_2, CO_2 and CH_4) in salt caverns. The Electrolysis–Methanation–Oxy-fuel (EMO) concept is designed to bring a closed-loop solution able to absorb renewable electricity surplus and recover it later, via the transient storage of O_2, CO_2 and CH_4. During the storage phase, the electric energy excess is used in an electrolysis process. The resulted O_2 is stored, while H_2 is combined with CO_2 in a methanation process. CH_4 formed is also stored. During the retrieval phase, electric energy is produced in a thermal generator, where the fuel is the methane and oxygen previously stored. The produced CO_2 is in turn stored for later use in the methanation process.

The main objectives of the FLUIDSTORY project are to study the operability, the safety and the integrity of O_2 and CO_2 storage in salt caverns as well as to investigate the medium to long term (2030-2050) requirements for reaching the energy efficiency and economic profitability of the EMO concept in France.

In order to achieve this goal, availability of storage volumes required by EMO development has to be investigated through systematic inventory of the existing salt caverns and geological study of suitable salt formations.

We present the main results of the inventory of the French salt formations and estimation of the French geological energy storage potential. It consists in an exhaustive inventory of salt formations in France with a special focus on halitic series. This review is based on public and accessible data.

Six sedimentary basins were targeted: Paris Basin, Aquitaine Basin, South-East Basin, Valence Basin, Bresse Basin and Upper Rhine Graben. For each basin, we looked for:

• the general lithostratigraphy: Position of the evaporitic series in the sedimentary pile and relationship between evaporites and the caprock;

• the geographical extension of the evaporitic series;

• the depth and thickness of the evaporitic series;

• Nature and content of insoluble rocks.

Two main conclusions can be drawn from this inventory:

• Salt bearing series of the Paris Basin (Lorraine region) are shallow and thin enough to satisfy the operational constraints of a small storage operated at low pressures.

• Evaporitic series of Apt-Forcalquier, Valence, Bresse or Mulhouse Tertiary basins may be interesting targets for larger storages. Their depths are great enough to increase operating pressures compared to the Paris Basin.vspace-0.5 cm

This work will be then valued in the techno-economical tasks of the project. Storage capacity needs for optimal use of EMO technology will be assessed in order to define the optimal location for the EMO technology deployment in France.

EXTREME ENVIRONMENTAL CHANGES IN THE EARLY JURASSIC AS DEDUCED FROM CARBON AND OXYGEN STABLE ISOTOPES OF BRACHIOPOD CALCITE

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The Early Jurassic was characterized by a globally warm climate, interrupted by periods of severe cooling that point to episodes of climate instability. Similarly, significant perturbations of the carbon cycle occurred, reflected by marked excursions in the marine carbonate and organic carbon isotope records. Long term time series of carbon and oxygen stable isotopes ($\delta^{13}C$ and $\delta^{18}O$ values) were published for the Cleveland (NW Tethys margin), the Lusitanian (proto-Atlantic), and High Atlas basins (SW Tethys margin). In order to have a better understanding of Early Jurassic environmental and oceanic perturbations, additional data are needed for the southern margin of Tethys, which likely played an important role on regional climate.

Here we present new $\delta^{13}C$ and $\delta^{18}O$ data for well-preserved calcite of brachiopod shells from western Algeria. Brachiopod specimens are precisely correlated to ammonite zones for the interval covering the late Sinemurian up to the late Toarcian (~190 to 175 Myrs). All the 144 selected specimens have been carefully screened for calcite preservation. The stable isotope profiles correspond to a composite of different taxa of rhynchonellids and terebratulids. The rejection of diagenetically altered brachiopod shell was made on the basis of the macro-and micro-textures of the shells. The primary layer, which is secreted out of isotopic equilibrium with oceanic water in modern species, was carefully removed with a dental tool under a binocular microscope. Samples for isotopic analyses were taken exclusively on the fibrous calcite of the secondary layer within the anterior part of the shell.

The $\delta^{13}C$ values we recorded span from +4‰ to -5‰ (VPDB) and $\delta^{18}O$ values from 0‰ to -6‰ (VPDB). Our results reveal the occurrence in western Algeria of $\delta^{13}C$ and $\delta^{18}O$ perturbations, namely negative $\delta^{13}C$ and $\delta^{18}O$ shifts already documented in other locations near the Sinemurian-Pliensbachian boundary, in the upper Pliensbachian and in the lower Toarcian strata. We also document the early Pliensbachian Ibex zone positive excursion event, noticed for Dorset and based on $\delta^{13}C$ and $\delta^{18}O$ measured on belemnites.

The new stable isotopes in brachiopods from Western Algeria confirm, therefore, the supraregional character of the environmental and oceanic perturbations occurring in the early Jurassic. Our data confirm that this interval was a period characterized by climatic instabilities, culminating with the early Toarcian Oceanic Anoxic Event.

LITHOLOGY AND STRATIGRAPHY OF DEVONIAN-CARBONIFEROUS SEDIMENTS OF BOLSHOI KARATAU AS THE STANDARDS OF OIL AND GAS DEPOSITS OF THE CASPIAN DEPRESSION

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The Devonian-Carboniferous sediments developed in the interval from the Frasnian stage to the Bashkirian stage and crop up on surface in Bolshoi Karatau (Southern Kazakhstan). Their thickness in some well-cropped and continuous sections exceeds 4000 m. According to modern paleogeographic construction, similar carbonate deposits of the Peri-Caspian depression accumulated in fairly close conditions. However, the roof of such deposits in the Peri-Caspian depression is immersion to depth of more than 2.5 km. In this regard, the well-cropped carbonate rocks of the late Devonian and the Early Carboniferous of the Big Karatau can serve as lithological and stratigraphic analogs of those the Peri-Caspian depression. Consequently, the results of detailed lithological and biostratigraphic study and age interpretation of carbonate sections in Karatau can be confidently extended to similar sections of the Peri-Caspian depression. This has great scientific and practical significance for studying the conditions of formation and forecast of new potentially oil and gas bearing areas. The rocks of the the Bolshoi Karatau are represented by full spectrum of the facies environment of carbonate platform: from deep-water basin facies, to carbonate platform margin and its inner zone as shelf lagoon and tidal plain of shallow water. In continuous and well-cropped sections, large flood events were documented, i.e. sea transgression or sea level rise and shallowing, i.e. regression with sharp drop in sea level. The changes of lithological composition and reservoir properties of rocks are associated with facies changes. This allowed with the necessary accuracy to perform lithostratigraphic correlation of sediments in sections of regions quite far from each other.

DEFORMATION, BASIN DEVELOPMENT, FLUID MIGRATIONS AND SHELF DEPOSITS ON THE LOWER TRENCH SLOPE OF THE HIKURANGI MARGIN (NORTH ISLAND, NEW ZEALAND)

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Since around 25 Ma, the Hikurangi prism, North Island, New Zealand, develops because of the subduction of the Pacific plate under the Australian plate. The highest part of this subduction wedge (e.g. trench-slope break) outcrops in the Coastal Ranges constituting an excellent onshore analogue for the analysis of subduction-related sedimentary systems. This syn-subduction sedimentation classically comprises turbidites, mass transport deposits and hemipelagites, deposited within trench-slope basins, but also well-developed mixed siliciclastic-carbonate shelf deposits. Although the relationships between the gravity-driven sedimentation and the structural evolution of the orogenic prism have been investigated, little work has been done on the characterization (facies, morphology, geometry, extension ...), stratigraphic architecture and controlling parameters of the lower trench-slope shallow water deposits.

In the Miocene of the Coastal Ranges, four sandy and/or carbonate shelf units, up to 120 m thick, are intercalated between deeper water sedimentary rocks. Sedimentary facies are dominated by upper shoreface to upper offshore sandstones and siltstones associated with mollusc-rich shell beds and rare limestone occurences.

In the study area, the limestones were deposited during the Early Miocene along a N-S trend that parallels a major fault zone, the Breakdown FZ, which is responsible for the uplift of a structural ridge at the edge of a trench-slope basin. The mapping and analysis of tubular carbonate concretions as well as the presence of solid bitumen within fault planes suggest that tectonically-induced fluid circulations occurred in the Breakdown FZ. Such focused fluid flows may have contributed to the local development of limestones.

In the Middle and Late Miocene, shelves developed above two main angular unconformities outlined by onlap shell-beds. The taphonomic analysis of intra-shelf shell beds and their correlation along proximal-distal profiles allowed the identification of seven main shell bed types distributed within Transgressive-Regressive (T-R) cycles with an estimated duration of 0.4 Ma: amalgamated shell bed (onlap shell bed, base of transgression), channelized shell bed (transgression and regression), starved shell bed (backlap shell bed, end of transgression), event storm and rapid burial shell beds (downlap shell beds, base of regression), wave current winnowed and sediment-dominated shell beds (during regression or as backlap shell beds at the end of regression). Following the angular unconformities, first T-R cycles show relatively well-developed transgressive system tracts suggesting an important topographic gradient with high sedimentary inputs. The following sequences display a much more marked asymmetry with a transgressive system tract reduced or absent.

Thus, both initiation and stop of shelfal sedimentation is related to the development of trenchslope basin edges in relation with the deformation of the subduction wedge while their stratigraphic architecture appears eustatically and physiographicaly controlled.

MULTI-SCALE GEOLOGICAL AND GEOPHYSICAL OUTCROP CHARACTERIZATION OF CONTINENTAL CARBONATES: THE EXAMPLE OF THE MIOCENE LACUSTRINE SERIES OF SAMOS ISLAND

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The recent discovery and subsequent exploitations of oil fields in the pre-Salt carbonates (South Atlantic) has increased the global interest in continental carbonates. These rocks are characterized by complex and diverse primary fabrics, and are also often modified by diagenesis, resulting in a complex pore network. Indeed, one of the main difficulty to tackle in these continental carbonates, is the high petrophysical heterogeneityand anisotropy- and the different factors that drive this heterogeneity. This work will focus on the Miocene continental carbonates of the East Aegean Sea as potential analogue of the Miocene reservoir of Western Anatolia. These series present a large variability of facies such as lacustrine, palustrine, fluvio-lacustrine, and tufa deposits.

One of the main goal of this work is to link the macro-and microstructure of these carbonates (controlled by sedimentology and diagenesis) with petrophysical properties and elastic wave velocities. What are the petrographic, acoustic and petrophysical signatures of these continental carbonates? What are the main factors which determine the propagation of elastic wave velocities? How to characterize the different scales of petro-physical heterogeneities from sample scale to field scale?

To answer these questions, different approaches will be presented. At the field scale, we carried out a seismic-refraction campaign to obtain wave velocities at a decametric scale. A photogrammetric campaign also provided 3D overviews of the studied outcrops and a visual estimation of the heterogeneity at outcrop scale. We also acquired sonic measurements on outcrops at a metric scale. Then, different plugs were cored (scale ~8 cm). Porosity, permeability, and ultrasonic P-wave and S-wave velocities were measured. Finally, we described and confronted the depositional facies and the diagenetic history of the different sampled facies, in term of i) texture, ii) mineralogy and iii) pore types, based on hand specimens and thin-sections. This study aims to present an integrated workflow of geological and geophysical characterization of continental carbonates at different scales, an essential step to modelling.

LONG-TERM CHANGES IN ALPINE PEDOGENETIC PROCESSES: EFFECT OF MILLENNIAL AGRO-PASTORALISM ACTIVITIES (FRENCH-ITALIAN ALPS)

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Human activities are known to modify soil properties; however, the associated modifications to soil processes are poorly documented, as they must be studied over long time scales. Lake Verney, which is on the Italian side of the Petit Saint-Bernard Pass in the French-Italian Alps (2188 m a.s.l) provides a sediment record of the last 11 000 cal. yrs BP. Analysis of multiple proxies within this sediment sequence, including sedimentological characteristics, mineral geochemistry (as determined using XRF and extractable Fe fractions), pollen and non-pollen palynomorphs (NPPs) and sediment DNA (sedDNA) analysis, is compared with analyses of soils and paleosols within this mountain ecosystem in order to understand the main drivers of long-term pedogenesis. The soils within the catchment are mainly Stagnosols, in which hydromorphic and rust horizons are characterized by low oxalate extractable Fe ratios. Most of these soils also display erosion patterns and successive stages of pedogenesis. We performed principle component analysis on both the sediment proxies and the soil geochemical properties to identify different sediment end members that reflect different types of soil horizons. These horizons are characteristic of specific soil processes and their associated land uses. During the first part of the Holocene, a decrease in the carbonate fraction in the sediment reflects the loss of carbonate material from soils that occurred as early postglacial vegetation became established. The migration of Fe-complexes until 6000 cal. yrs BP indicates the development of Podzols in the catchment. The first signs of human land use are detected at 4300 cal. yrs BP according to analyses of sedDNA and NPPs. Increases in the input of terrestrial organic matter, associated with forest clearance suggests degradation of the surface horizons of the Podzols. Erosion increased during the Roman Period due to sheep grazing. Then, while erosion was still increasing, the Podzols developed into Stagnosols after the Middle Ages with cow grazing which is consistent with the current functioning of the soils. The history of the paleosols and archaeological levels within the study area confirm the model of soil evolution inferred from the lake sediments and allow us to characterize the human-induced "metapedogenetic phase" of the evolution of the soil cycle. Anthropo-pedogenesis may define the development of soils during the Anthropocene. The main consequence of this change in the functioning of the soils is a reduced sequestration of soil carbon.

PROGRESSIVE AND REGRESSIVE SOIL EVOLUTION PHASES IN THE ANTHROPOCENE

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Soils have a substantial role in the environment because they provide several ecosystem services such as food supply or carbon storage. Agricultural practices can modify soil properties and soil evolution processes, hence threatening these services. These modifications are poorly studied, and the resilience/adaptation times of soils to disruptions are unknown. Here, we study the evolution of pedogenetic processes and soil evolution phases (progressive or regressive) in response to humaninduced erosion from a 4000-year lake sediment sequence (Lake La Thuile, French Alps). Erosion in this small lake catchment in the montane area is quantified from the terrigenous sediments that were trapped in the lake and compared to the soil formation rate. To access this quantification, soil processes evolution is deciphered from soil and sediment geochemistry comparison. Over the last 4000 years, first impacts on soils are recorded at approximately 1600 yr cal. BP, with the erosion of surface horizons exceeding 10 t km^2 y^{-1}. Increasingly deep horizons were eroded with erosion accentuation during the HigherMiddle Ages (1400–850 yr cal. BP), reaching 1000 t km^2 y-1, and leading to the remobilization of carbonated and poorly weathered material, hence rejuvenating soil development. Erosion exceeded the soil formation rate and constituted a regression in the development of soils. The tolerable erosion limit is thus defined for erosion from 25 to 30 t km^2 y^{-1}. Beyond this limit, the sustainability of the agroecosystem is limited and ecosystemservices decrease. Afterwards, pedogenesis evolved again fromprogressive (700–300 yr cal. BP) to regressive (300 yr cal. BP-today) phases. Erosion was less important during the last 700 years than during the Middle Ages but with the same weathering stages, indicating that soils were deeply affected during the Middle-Age and have yet not recovered. Our results highlight the importance of the human factor in the pedogenesis over last millennia and suggest that the studied agro-ecosystem entered the Anthropocene 1400 years ago.

PALEOGEOGRAPHIC CONSTRAINTS ON CONTINENTAL-SCALE SOURCE-TO-SINK SYSTEMS: NORTHERN SOUTH AMERICA AND ITS ATLANTIC MARGINS

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Our work aims at setting the evolving boundary conditions of erosion and sediments transfer, transit, and onshore-offshore accumulations on northern South America and along its Atlantic margins. Since the Early Mesozoic, the source-to-Sink system evolved under the interplay of four main processes, which are (i) volcanism and arc building along the proto-Andes, (ii) long-term dynamics of the Amazon incratonic basin, (iii) rifting, relaxation and rejuvenation of the Atlantic margins and (iv) building of the Andes. We compiled information available from geological maps and the literature regarding tectonics, plate kinematics, magmatism, stratigraphy, sedimentology (including paleoenvironments and currents) and thermochronology to produce a series of paleogeographic maps showing the tectonic and kinematic framework of continental areas under erosion (sources), by-pass and accumulation (sinks) over the Amazonian craton, its adjacent regions and along its Atlantic margins. The maps also allow assessing the relative impact of (i) ongoing Pacific subduction, (ii) Atlantic rifting and its aftermath, and (iii) Atlantic slab retreat from under the Caribbean domain on the distribution and activity of onshore/offshore sedimentary basins. Stratigraphic and thermochronology data are also used to assess denudation / vertical motions due to sediment transfers and lithosphere-asthenosphere interactions. This study ultimately aims at linking the sediment routing system to long-wavelength deformation of northern South America under the influence of mountain building, intracratonic geodynamics, divergent margin systems and mantle dynamics.

INFLUENCE OF DEPOSITIONAL CONDITION AND STRATIGRAPHIC CONTEXT ON CHEMICAL COMPOSITIONS OF CRETACEOUS GLAUCONITES IN PENINSULAR INDIA

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An integrated investigation involving field, mineral chemistry and petrography reveals the effects of substrate, depositional setting and stratigraphic condensation on composition of three coeval Cretaceous glauconites in the peninsular India. These authigenic glauconites form in wide ranging depositional environments from littoral to outer shelf through middle shelf. Glauconite represents both transgressive systems tract and highstand systems tract, involving both siliciclastic and carbonate lithologies. It occurs as altered form of faecal pellet, K-feldspar, quartz and mica grains and as infillings within the bioclasts. The relationship between K_2O and Fe_2O_3 (total) content of glauconites reveal distinct clustering. The K_2O content of both incipient and evolved varieties of glauconite forming within K-feldspars frequently exceeds 8%.

Glauconites forming within the faecal pellets are found to be 'highly-evolved' to 'evolved', containing 6.5 to 8% K_2O and 25 to 30% Fe_2O_3 (total). While glauconites forming within the tiny pores of bioclasts are 'slightly-evolved', containing 4 to 6% K_2O and ~20% Fe_2O_3 (total). The K_2O content of glauconites exhibit more or less similar values across a transgressive systems tract, while concentration of glauconite records an appreciable increase close to the maximum flooding zone (MFZ). The Fe_2O_3 (total) contents of glauconites forming within shelf deposits always exceed 25% while those formed in the littoral environment rarely exceeds 15%. The low Fe_2O_3 (total) content of littoral glauconites is related to the restricted mobility of Fe ions. The origin of glauconite infillings and faecal pellets is best explained by a combination of 'layer lattice' and 'verdissement' theories while the glauconites formed by alteration of feldspar, quartz and mica grains broadly follow the evolution trend supporting the 'replacement' theory. Glauconites may, further undergo post-depositional alteration causing depletion of both K_2O and Fe_2O_3 content, related to 'reverse glauconitization' by meteoric water actions. The REE patterns of glauconite occurring close to the MFZ bear similarity to seawater, while samples representing the upper part of HST bear signatures of relic substrates in them. Therefore, REE concentrations of glauconites are closely linked to the degree of glauconite maturation, which in turn depends on the stratigraphic condensation. Major findings of the resent investigation include (i) K_2O content of glauconite depends largely on the substrate composition, as a high K_2O content of glauconite may be genetically related to k-feldspar substrate, (ii) a low Fe_2O_3 content of glauconite characterizes shallow littoral glauconites, (iii) high abundance of glauconite is a better indicator of the maximum flooding zone, rather than the K_2O content, and (iv) REE pattern of glauconites close to the maximum flooding zone bears a seawater signature, while relics of substrate influence the pattern in the rest of the sequence.

RECORD OF HYDROTHERMAL FLUID CIRCULATION IN THE MESOZOIC CARBONATES OF THE ADRIATIC CONTINENTAL PALAEOMARGIN (SOUTHALPINE DOMAIN; PIEMONTE ALPS, NW ITALY)

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Evidence of a widespread circulation of hydrothermal fluids has been recently recognized in Middle Triassic–Lower Jurassic pre-and syn-rift successions of the Adriatic palaeomargin of the Alpine Tethys, presently preserved in the western Southalpine Domain (Piemonte Alps, NW Italy). The products of this circulation are mainly represented by vein and breccia cements, as well as a local dolomitization of the host rocks.

In the proximal part of the margin (Monte Fenera–Sostegno), Middle Triassic peritidal dolostones and the lower part of the overlying Lower Jurassic open-marine sediments are crossed by veins cemented by coarsely crystalline saddle dolomite. Based on stratigraphic and petrographic evidence, the precipitation of dolomite cements can be constrained within the middle Early Jurassic (pre-late Pliensbachian), when the host rocks were buried to a depth of some tens to a maximum of a few hundred metres and thus very close to surface temperature. Despite the shallow burial depth, fluid inclusion microthermometry shows that fluid temperatures were relatively hot (80–150°C), thus indicating the hydrothermal character of the fluids.

In the distal margin (Montalto Dora–Vidracco), a polyphase history of host-rock fracturing is recorded, with at least three generations of veins cemented by carbonates (calcite and dolomite) and quartz. The relations among these veins and the host rocks and sediments document that the vein opening and cementation occurred partly before and partly during or shortly after the deposition of the syn-rift clastic succession, and thus at shallow burial depth. On the other hand, fluid inclusion microthermometry on both quartz and dolomite cements indicates a fluid temperature of 90–130°C, again pointing to hydrothermal fluids.

The hydrothermal vein and breccia cements in the carbonate sedimentary succession of the Adriatic palaeomargin document a fault-related, deep-reaching fluid circulation, which was at least in part coeval with, and possibly related to, the Early Jurassic rifting phases. The change of the hydrothermal paragenesis from the proximal (only dolomite) to the distal margin (dolomite, calcite and quartz) probably mirrors a difference in fluid flow pathways and fluid–rock interactions.

TSR IN ITS GEOLOGICAL FRAMEWORK: CASE STUDY OF THE FRENCH ALPS CARNIAN EVAPORITES

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The Nappe des gypse formation in the French Alps is a Carnian Evaporites deposit that contributes to major decollements and hence horizontal thrust sheets displacements in the alpine mountain range. Extensive study of mineralogy, fluid inclusions, organic matter, S, C, O stable isotopes lead to characterize thermochemical sulfate reactions during burial and uplift.

The mineralogical as well as geochemical study of dolomite allowed to distinguish sedimentation inherited often stromatolitic carbonates as well as recristallisation of white dolomite at 350°C within boudin deformation features. Yet, occurrence of much more negative $\delta^{13}C$ dolomites also occur and suggest precipitation from CO_2 derived from the organic carbon pool, hence suggesting the presence of a hydrocarbons oxidation process. Indeed, the presence of organic matter is recognized within dolomitic stromatolite as well as black-shale source-rocks. Also, hydrocarbons were identified within fluid inclusions. Closer analysis of the hydrocarbon content of fluid inclusions reveals the presence of aliphatic, aromatic, sulfurized as well as oxygen bearing hydrocarbons. A detailed study of the fluid inclusions contents and fluid reactivity between 200°C and 300°C revealed a fully reactive system typical of TSR and allowed to constrain the P-T-composition of fluid entrapment conditions.

The study of sulfur lead to identify various redox states: sulfate, elemental sulfur, and iron sulphides within the mineral paragenesis, while H_2S and polysulfides were recognized in the fluid inclusions. The mineralogical, geochemical and isotopic information collected brought full documentation of Thermochemical Sulfate Reduction in a closed system. Consideration of the structural evolution of the Nappe des Gypse formation provided temporal constraint to the deformation stages of exhumation. The overall study may provide general background to TSR conditions in deeply buried settings (e.g. foreland basins).

IMPACT OF VOLCANISM ON CARBONATE SEDIMENTATION IN THE CANTERBURY BASIN, USING ONSHORE VOLCANIC STRUCTURES AS ANALOGUES FOR BURIED VOLCANOES IN OFFSHORE NEW ZEALAND

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The Canterbury Basin on the East Coast of New Zealand's South Island is a failed rift initiated during intracontinental extension (~105 Ma to ~86.5 Ma) during the break-up of Gondwana and the creation of the Zealandia Continent. Evidence for magmatic activity through the Canterbury Basin is present both onshore and offshore from the rift phase (~105-86.5 Ma), to the post-rift/drift phase (~86.5 Ma-23 Ma) and since the onset of the recent oblique plate boundary convergence (~23 Ma) until ~2 Ma. Seismic reflection lines, well data and outcrop show evidence for igneous activity both onshore and offshore. Onshore intrusive and extrusive rock outcrops are numerous and range from mafic to felsic in composition. The combination of outcrops and seismic reflection lines emphasizes the impact of volcanism on sedimentation in the basin, both syn-depositional and post-burial.

Offshore, criteria for identification of possible volcanic complexes on mainly 2D seismic reflection lines include high amplitude dome shape reflectors and low amplitude internal reflectors deepening away from the axis of the dome shape; mapping shows a rounded shape if visible on several seismic lines. The result of this mapping shows continuous volcanic activity in the Canterbury Basin that was widely distributed. They range in diameter from 30 km volcanic complexes.

Numerous onshore examples can be used to understand the distribution and geometry of volcanic activity in offshore seismic lines. In the Oamaru region of the Canterbury Basin, outcrops of Late EoceneEarly Oligocene sill complexes and volcanic cones of 500 m to 2 km diameter illustrate the impact of volcanic activity on sedimentation and diagenesis. The Oamaru volcanic multi-cone complex produced a regional high that became the setting for a cool-water carbonate factory during the maximum inundation of the Canterbury Basin around the Late EoceneEarly Oligocene. On top of the volcanic cone a bryozoan carbonate factory developed while on the flanks of the edifice deeper water impure wackestone and calcareous siltstones were deposited. On the palaeohigh, early cool-water diagenesis affected the bryozoan grainstone causing dissolution of aragonitic shells and precipitation of early cement preserving inter and intra granular primary porosity. In this onshore example, facies and diagenetic variability are controlled by the presence of the structural high formed by the cone complex.

Onshore examples show the impact of volcanoes on sedimentation both during and after their emplacement. They illustrate the range of scales for volcanic structures that might be found offshore as well as the complexity of multi-cone structures that might not show clearly on seismic lines. They also provide reservoir analogues for possible volcanic complexes identified in offshore Canterbury Basin.

IMPACT OF FAULTING ON THE LATE MESOZOIC AND YOUNGER SEDIMENTARY FILL OF CANTERBURY BASIN, NEW ZEALAND

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Zealandia comprises continental crust which rifted from Gondwana during Cretaceous breakup (~105 Ma). The geometry, thickness and lithologies of the Canterbury Basin on the East Coast of New Zealand's South Island, were strongly influenced by basement structure and the post 105 Ma tectonic history. Four tectono-stratigraphic phases are recognized: (i) Permian-Early Cretaceous tectonic accretion in eastern Gondwana which produced an accretionary prism during subduction, (ii) mid-Cretaceous rifting that was a precursor to Gondwana breakup, (iii) Late Cretaceous to Oligocene passive margin formation during post breakup drift and, (iv) Oligocene-Recent contraction with the onset of oblique plate-boundary convergence.

Interpretation of mainly 2D seismic reflection lines and petroleum wells indicates that mid-Cretaceous rifting (~105-86.5 Ma) formed in association with NE-SW, E-W and NW-SE trending normal faults. These faults strike approximately parallel to the margins of the Zealandia continental crust and accrued displacement synchronously. They formed due to distributed extension prior to Gondwana breakup, with maximum throws of 2-3 km typically greatest on NE striking faults sub-parallel to the mid-ocean ridge system separating New Zealand and Antarctica.

In the northern offshore basin, deep seismic reflectors within basement highlight a paleo-topography at the time of rifting not controlled by rift faults. These structures were likely inherited from the pre-rift accretionary phase oriented E-W and may have influenced sedimentation during the rift and post-rift phases.

Rift-fault displacements produced fault-bound structural highs with adjacent under-filled half graben depocentres. Rifting produced basin and range topography with the potential for organic-rich sedimentation into lakes at under-filled depocenters before post-rift transgression. In such under-filled basins, the horst blocks produced structural highs which provided a local sediment source for several million years. Inactive fault 'scarps' were subsequently buried by prograding Late Cretaceous sedimentary wedges of ~150 km^2 sizewhich downlap rift strata. These wedges likely represent either fan delta or submarine fan deposition during a general deepening of water depths and regional subsidence in the drift phase.

At the end of the rift activity ~86.5 Ma, Canterbury Basin displays pervasive structural highs forming potential barriers to the marine transgression. Analysis of onlap over prograding wedges and structural maps show that the transgression likely came into the basin from its north-eastern edge, relocating the shoreline westward with time. By the end of the Paleocene, most of the structural highs were drowned, but their presence still impacted the sediment thickness as a result of differential compaction. The Neogene to present day convergence only influenced the offshore basin structure along the coast line where folds and fault inversions locally produced uplift.

The rift-drift sedimentary succession offers considerable potential for source, reservoir and seal rocks in sub-basins. Due however to the structure of the basin, the faulting and the complex sedimentation patterns these sedimentary units are likely to be discontinuous, this may locally impact basin prospectivity. In addition, Neogene shelf-progradation, generated by regional uplift in the central South Island, deposited a sedimentary wedge up to 2.2 km thick, which produced burial maturity and a potential seal for the rift-drift succession (NZPAM, 2014).

AN INTRODUCTION TO THE PHYSICAL STRATIGRAPHY AND FACIES OF THE UPPER CRETACEOUS HELMINTHOID FLYSCH, WESTERN ALPS AND NW APENNINE

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The Upper Cretaceous "Helminthoid Flysch" outcropping in the Western Alps and NW Apennine is a thick succession of pure siliciclastic, pure carbonate-clastic and mixed-sediment turbidite beds, some of which attain 35-38 m. These beds, originally deposited under the CCD in an oceanic realm separating the palaeo-Eurasian and palaeo-Adria plates, are now detached from their lithospheric basement and piled-up in allochtonous cover nappes that are overthrust on the post-Eocene foredeep deposits on both sides of the orogenic belt. Based on structural position in the nappe stack, sandstone petrology and common lithostratigraphic criteria such as the carbonate / siliciclastic ratio, authors defined and mapped different structural-stratigraphic units, which were assigned a palaeogeographic significance. Original field work however demonstrates that most of carbonate-clastic and mixed-sediment beds thicker than approximately 1.5 m are correlated across the nappe boundaries over present-day distances that exceed 400 km, suggesting an original continuity in a deep, narrow, elongate trench.

The bed-by-bed correlation enabled us partly reconstruct the basin-fill architecture. We distinguish 3 main situations:

-an "axial" setting characterised by thick (> 7000 m) complete successions dominated by "mixed" and carbonate-clastic megabeds;

-an outer (western) margin where thinned-out "mixed" beds alternate with coarse siliciclastic marginal wedges supplied from the west;

-an inner (eastern) sector where incomplete successions, resting on severely dismembered older deep-water deposits, contain significant proportions of shale-rich, lithic-siliciclastic beds supplied from the SE that are missing in the western outcrops.

Thanks to the tight framework of time-lines, we recognised subtle progressive unconformities expressed by convergent onlaps on top of some major megaturbidites and gradual changes of the lithofacies proportions. We then divided the succession into 8 zones (A-H) recording a progressive westwards retreat of coarse quartz-feldspathic siliciclastic wedges, an upwards loss of frequency of carbonate-clastic and mixed-sediment beds and a parallel increase of fine-grained, accretionary-wedge derived lithic-rich siliciclastics.

The accurate bed correlation pattern also enabled us establish genetic links between the western siliciclastic marginal wedges and the basin-plain mixed beds. There is consistent field evidence that some, but not all of the coarse quartz-feldspathic beds evolve downstream into mixed-sediment and carbonate-clastic beds via entrainment of carbonate mudstone from the substratum and progressive segregation /abandonmen of the sand fraction. For the "small" events, the transition is observed at the outcrop scale over few hundred meters. The "common" mixed-sediment beds laterally replace the pure siliciclastics in few km to tens of km.

We assume the facies change to occur in the same way, although we cannot document it because of outcrop discontinuity. Fine-grained lithic-rich siliciclastic sourced from the SE may also entrain some carbonate mudstone in the basin but seldom transform into true mixed beds. Basin-wide megaturbidites that drive the first-order correlation do not display any obvious genetic link to the coarse siliciclastics sourced from the W but rather onlap the marginal wedges and their mixed-sediment fringes with a gradual thinning of the sandstone division accompanied by extensive development of deflection/reflection features. Their origin must be probably sought in a still unknown axial feeder system.

TECTONIC AND CLIMATIC CHANGES IN THE UPPER CRETACEOUS SANFRANCISCANA BASIN (SOUTHEAST BRAZIL) BASED ON FACIES AND PALEOSOLS CHARACTERISTICS

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The Sanfranciscana Basin is an intracratonic basin in central-east of Brazil that comprises Phanerozoic continental sequences. During the Cretaceous this basin was filling by alluvial, aeolian, and fluvial deposits, whose facies and paleocurrent data indicate diferent source-areas from south to north. Stratigraphic analysis based on outcrops and well-logs, aided by paleosols studies have identified two second order sequences that are bounded by regional unconformities (Sequence 1 and 2). The unconformity K-0 is related to the extensional tectonic processes associated to the Gondwana break up, responsible to the beginig of Cretaceous sedimentation in Sanfranciscana Basin in the Early Cretaceous. The Early Cretaceous Sequence 1 (Areado Group) is interpreted as a second-order sequence, formed by lacustrine and aeolian deposits, constituting a Lacustrine-Aeolian Systems Tract. The unconformity K-1 overlies the Early Cretaceous deposits (Sequence 1) in the south of the basin and the Precambrian basement in the north. Unconformity K-1 that was generated in the Late Cretaceous (Cenomanian-Coniacian) is related to the origin of the Alto Paranaíba Uplift (SAP) in the south of the Sanfranciscana Basin. Overlying the Unconformity K-1, volcanic rocks (Patos Formation), alluvial deposits (Capacete Formation), aeolian deposits (Posse Formation) and fluvial deposits (Serra das Araras Formation) display progradational characteristics of the two third-order sequences: Sequences 2A and 2B, constituted by the Alluvial and Aeolian-Fluvial Systems Tracts, respectively, and separated by the Unconformity K-1A. Appling the concept of accommodation space (A) and sediment supply (S) we identify specific stacking patterns of depositional systems, relating the changes in the sedimentary styles to the different stage of tectonic and climatic evolution of the basin. The first stage is related to the pre-Cenomanian tectonism, responsible to the origin of erosive surface which preceded the volcanic rocks in the south (Patos Formation), and aeolian deposition in the north (Posse Formation). The second stage was related to the alluvial and fluvial systems developing from south to north of the basin (Capacete and Serra das Araras formations), probably related to climatic changes. Facies, paleosols and stratigraphic architecture, suggest that A/S ratio was neutral in the late stage of the Sequence 1 in the south of basin, whereas in the north the rate was negative. During the evolution of the Sequence 2, there was an increase of the A/S ratio (Sequence 2A) followed by a decrease in the A/S ratio (Sequence 2B). Aeolian facies and paleosols (Sequence 1), volcanic rocks and aeolian facies (Sequence 2A), alluvial and fluvial facies (Sequence 2B), indicate tectonic and climatic changes that can be correlated to the other Cretaceous continental basins in South America.

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TECTONIC AND STRATIGRAPHIC EVOLUTION OF THE UPPER CRETACEOUS PARECIS BASIN IN CENTRAL-WEST OF BRAZIL

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With the breakup of the supercontinent Gondwana, the South American Plate has undergone an intense process of tectonic restructuring that led to the genesis of the interior basins. The Upper Cretaceous sedimentary sequence of the Parecis Basin, lies unconformably on volcanic rocks of the Anari and Tapirapua formations (Lower Jurassic) and Lower Cretaceous Rio Ávila Formation sandstones. This unit consists of alluvial conglomerates and sandstones at the base (Salto das Nuvens Formation) and aeolian sandstones on the top (Utiariti Formation). From facies analysis and stratigraphic architecture, a paleoenvironmental model was elaborated, including tectonic and climatic evolution during the Late Cretaceous. Using the concept of stratigraphic base level and / or the ratio of accommodation space and sediment supply (A/S), was identified the stacking pattern of alluvial and aeolian, corresponding to different stages of Juruá Tectonic. Changes in depositional style correspond to two distinct tectonic moments occurring within the South American plate. The first associated with post-volcanic thermal subsidence of the Early Cretaceous (Tapirapua volcanic event), and the second moment associated with the uplift occurred in the Late Cretaceous (Vilhena and Serra Formosa Arcs). The events of sedimentation began after the genesis of a regional unconformity (unconformity K-1) between the Early and Late Cretaceous. During the Late Cretaceous the Parecis Basin took an alluvial sedimentation cycle (Sequence 1A) followed by aeolian cycle (Sequence 1B). The first stage records an increase in the A/S ratio where it developed alluvial fans reworked by braided rivers and aeolian process (High Accommodation System TractHST). Progressively the accommodation space was decreasing, and draas landforms was developed (Low accommodation System Tract – LST). In the final stage, the A/S has become negative and unconformity K-2 was made. The facies from the base to the top mark the climate evolution in the basin, from humid to the dry.

Acknowledgments: Project FAPESP 2015/17632-5: Sedimentation and pedogenesis of the Upper Cretaceous of the Bauru, Sanfranciscana, Parecis, and Neuque Basins.

FACIES VARIABILITY, DEPOSITIONAL SYSTEMS AND FRACTURE CHARACTERISTICS AROUND A CARBONATE STRUCTURAL HIGH: THE MATERA HIGH (SOUTHERN ITALY) AS A TERTIARY ANALOGUE FOR SUBSURFACE SYSTEMS IN THE MEDITERRANEAN SEA

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The vertical and lateral facies variabitily related to the different depositional environments combined with the distribution of different fracture characteristics have relevant impacts on carbonate reservoir properties. In this study, we exhamine the impact of these features in a carbonate system composed of vertically-coupled porous-tight carbonates exposed aroud the Matera High.

The Matera High represents normal-fault bounded structure made up of Upper Cretaceous lagoonal carbonates of the Apulian Platform. Plio-Pleistocene carbonate deposition took place around the Cretaceous high before the beginning of the typical siliciclastic deposition of the Southern Apennines foredeep. At late Pliocene times, the horst was an isolatde carbonate paleo-island where erosion and karst processes took place. The paleo-island was fringed by transgressive shallow water carbonates with typical high-energy facies associated to a ramp depositional environment. These comprise litho-bioclastic and coarse-grained lithologies derived from the erosion and reworking of the Mesozoic bedrock. They are characterized by very high porosity and permeability incontrast to the tight carbonate facies of the Cretaceous sequence, and by the total absence of mud and clay components. Upwards, these shallow-water lithoclastic carbonates deposits are marked by an unconformity that highlights the drowning of the ramp and the passage to basinal conditions, with the deposition of marls and clays.

The Matera High is asymmetric and controlled by normal faults that acted in differently with respect to the orientation of regional stress field. The morphological setting and asymmetry of the structure led to the development of different depositional systems around the carbonate islands. The northern side is characterised by a gently-dipping carbonate ramp, where typical medium-to-coarse grained shoal deposits are present. The carbonate sequence is composed of amalgamated thick calcarenites and facies show good-to-very good interparticle porosity (20-35%). The south-western side was characterised initially by a series of cliffs and beaches where coalescent fans rich in Cretaceous carbonate clasts were deposited and reworked by currents and wave action. The basal part of the sequence is marked by conglomerates passing upwards into calcarenites associated to sand bodies. The lateral variability of the facies in the lower part of the sequence is very high as well as their petrophysical properties. The different facies within the porous carbonates are affected by deformation bands developed during the foreland uplift. Their vertical variation is related to the mechanical stratigraphy whereas their lateral variation and distribution is controlled by the normal faults involving the tight Cretaceous carbonate substratum.

The horst shows different lithologies and sedimentary bodies related to the occurrence of different processes linked to the morpho-tectonic configuration of the substratum and to the hydrodynamic conditions. Moreover, the tectonic deformation developed different fracture networks in the porous and tight carbonates over time. With all of its characteristics, the Matera High can be considered a good analogue for Tertiary subsurface carbonate systems in the Mediterranean Sea and the case here presented offers a good example on the complexity of porous-tight carbonate reservoirs.

CONTRASTED STYLES OF MARINE FLOODING SEDIMENT RECORD RELATED TO WAVE EXPOSURE

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Coastal marine floods related to tsunamis or storm surges are among the costliest and deadliest natural hazards. Moreover, the risks associated with these events are expected to increase in response to future sea-level rise, higher storm amplitudes and frequencies and growing coastal populations. Consequently, it is crucial to better understand marine floods, also referred here as submersion events. Records of past marine floods are mainly based on tide gauge measurements and historical archives but they are limited to the last few centuries and they include uncertainties and biases, especially for older periods and are unavailable for many coastal areas. Consequently, sediments are key archives of past marine floods and there is a need to improve our analysis and interpretation of these archives in various environmental settings.

In the literature, a common approach in paleotempestology is to look for grain-size anomalies in the backbarrier sediment-fill, related to the overwash and erosion of the sandy barrier in storm conditions. In fact, (i) many coasts in the world, including many estuaries and deltas, are not bounded by a sediment barrier, and (ii) storm surge sedimentation usually extend further inland with respect to the limit of sand deposition and only consists in silty mud deposit.

Sediment records of two contrasting backshore coastal marshes, located on the SW coast of France, known to be flooded by similar storm events (7 marine floods in the last 250 years, inferred from historical archives), have been investigated using a multiproxy approach. One Marsh is located in a wave-exposed coast and isolated from the sea by a sediment barrier, whereas the other one is located in a sheltered estuarine environment and isolated from the sea by a dike. Grain size, foraminiferal and shell content and stable isotopes analysis have been conducted on one core from each marsh. An age model was obtained using ^{210}Pb, ^{137}Cs and ^{14}C. Core data combined with historical maps give evidence of a typical estuarine backfilling, top of the Holocene regressive parasequence, including an intertidal mudflat at the base and a freshwater backshore at the top. Despite the absence of grain size anomalies, marine flood-related sedimentation in the backshore area of both marshes is identified by a mixture of marine and terrestrial features, including marine fauna, vegetation debris and variation in the $\delta^{13}C$ signature of the organic fraction. Very low sedimentation rates between flood events and/or bioturbation prevents the identification of individual episodic marine floods in the sediment succession. Comparison of the two sedimentary successions shows a variation in the foraminifera content deposited after marine submersions. Foraminifera are monospecific and originate from the upper tidal mudflat in the sheltered marsh; whereas in the backshore marsh located in a wave-exposed environment, they show higher diversity and originate from both shallow and deeper water marine environments. This study shows that wave exposure can control the faunal content of submersion sediment records in coastal marshes and that wave exposure can be identified from the sediment record.

WASHOVER DEPOSIT: SEDIMENT RECORD OF OVERWASH EVENTS RELATED TO EXCEPTIONAL INFRAGRAVITY WAVES

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Studies of sediment successions deposited after recent and well-documented catastrophic events are helpful for the interpretation of older deposits and the analysis of their forcing parameters. Washover deposits are among the most remarkable sedimentary signatures of dune breaching and coastal inundation. They are resulting from the overwash or breaching of the littoral barrier and the associated reworking of eroded sediment deposited in the backbarrier area. Overwash of the barrier leading to washover development can be related either to storms or tsunamis but the distinction between these two processes, based on the depositional record, is still a matter of debate. There is indeed tremendous abundance of papers focused on the sedimentology of washovers fans but relatively few papers bring together geomorphological and sedimentological studies of storm related deposits and in-situ measurements and/or modeling of coastal hydrodynamics processes. Therefore, studying recent welldocumented washover deposits, combining sedimentological and hydrodynamic investigations is a key approach to identify the processes governing the washover deposition and to analyze their sediment record within the washover. During the winter of 2013-2014, the coasts of the Bay of Biscay experienced an exceptional wave climate (the most energetic along the European Atlantic coasts since at least 1948), leading to dune breaching and washover deposition at many locations, including the Gatseau Spit (South of Oléron Island, France). Field observations, aerial photographs, topographic measurements, GPR investigations, trenches and cores, grain size analysis and magnetic fabric measurements) were carried out and complemented with hydrodynamic modeling of tides, storm surges, short waves and infra gravity waves in order to compute maximum runup during the winter of 2013-2014. Such a transdisciplinary approach led to propose that: (i) large overwash events occurring during the winter of 2013-2014 were mainly driven by infra gravity (IG) waves combined to high tides; (ii) the washover elongated outer shape was strongly controlled by the antecedent morphology of the back-barrier area; (iii) one overwash flow driven by one IG wave is recorded by one normally graded lamina composed of quartz sand at base and heavy minerals sand at top; (iv) dominant settling of the particles from a suspension during sedimentation occurred in the end of each overwash flow in response to flow velocity decrease; (v) laminae can be grouped in laminasets generally composed of thinning upward laminae, related to overwash flow depth decrease during falling tide, and to erosion of basal laminae by highest overwash flows (occurring more likely around the high tide); (vi) the number of laminasets in a proximal position is in the same order of magnitude as the number of modeled highest runup events, offering an almost complete record of overwash events that occurred during the winter 2013-2014.

IMPROVING THE DUMPING OCTEVILLE SITE MONITORING IN A DYNAMIC ENVIRONMENT (BAY OF SEINE, ENGLISH CHANNEL)

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Harbours need to maintain a sufficient water column to allow good navigation. Dredged sediment may be deposited at sea. Nevertheless, they may have different physical and chemical characteristics compared with the sediment in place which generate multiple effects on the benthic environment. Studies on the impacts of such eco-environmental disruptions are numerous and necessary. Unfortunately, no sampling schedule patterns have been proposed despite the OSPAR Convention (www.ospar.org) covering Northwest Europe, and the London Convention (http://londonprotocol.imo.org), neither of which impose a "uniform" design for monitoring programmes. What is the best way of measuring sediment cover around a site used for dumping to obtaining the best representation of the sediment coverage? In the eastern Bay of Seine (France), sediment management and dredging practices ("Grand Port Maritime" Rouen and Le Havre) constitute one of the main anthropic pressure and driving factors in the morphological evolution of the Seine estuary and its sedimentary hydrodynamics. This study is focused on the environment surrounding the Octeville dumping site (used by the "Grand Port Maritime du Havre"). Two sampled strategies are tested (regular grid or radial lines) to discuss of the best strategy and the necessity to collect sample replicates and their optimal number. The results show that the sampling strategy used to monitor the effects of dredged deposits on their surrounding environment can lead to different interpretations which remains problematical. It appears that sediment sample replicates may or may not necessary, depending on the studied area (offshore, coastal or dumping area), the prevailing environmental forcings before sediment sampling (flood, storm or tide) and the combination of these two factors. Concerning Octeville dumping site and when the monitoring of a dumping site implies the drawing up a sedimentological map, it is of crucial importance to use a regular grid sampling strategy. This is the only strategy that allows us to establish maps based on the currently used interpolation methods, thus, the interpolated surface-area between the sampled sites can be considered with greater confidence. The proposed modus operandi allows to optimize both the confidence on the obtained results and the cost of the sediment studies (sampling and laboratory analysis). These results are based on the sediment fine fraction, which is considered as a key environmental component due, for example, to its strong association with the structure of benthic faunal communities as well as its role in the build-up of pollutants.

COLLECTING GEOLOGICAL SUBSURFACE DATA FOR ENERGY STORAGE ASSESSMENT AS A PART OF THE EUROPEAN ESTMAP PROJECT (ENERGY STORAGE MAPPING AND PLANNING)

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In Europe, most data relevant to energy storage exists in a fragmented form. The major work in the ESTMAP project therefore consisted of compiling existing data in a unified database and exploiting it to optimize energy systems planning. Geologists, engineers and system modellers joined forces to define the format and the content of a database of both subsurface (i.e. in sedimentary basins) and above surface storage sites (existing, planned and potential). The idea is to ensure that the newly compiled dataset will fit the needs for robust modelling, planning and designing on a coherent basis and comparable among Member States and other European neighbouring countries. One of the project output consisted of a geographical database providing information on distribution and expected capacity of existing and future energy storage sites in Europe. Both subsurface storage options (hydrogen, compressed air, natural gas, underground pumped hydro, etc.) and above ground storages (pumped hydro, LNG, liquid air, etc.) were taken into account.

In this project, BRGM, assisted by TNO, CGS and VITO, was in charge of data collection for underground energy storage (mainly in sedimentary basins), in order to gather readily available and public data on existing and future potential storage sites. These data incorporate the geographic location, geological description and characterization, subsurface properties, and feasibility and capacity assessments of the subsurface reservoirs (aquifers, salt formations and caverns, depleted hydrocarbon reservoirs...).

A co-operation with European national geological institutions has been established; the ESTMAP geological subsurface database populates data from EU member countries, the countries of the European Free Trade Association-EFTA (4 countries) and the Member of the Energy Community (8 countries). About 1000 subsurface sites spread around Europe have been identified during the subsurface data collection. All of them have assessment information per technology, in term of proven, likely, possible, unknown, or unlikely feasibility of energy storage. All these data were forwarded for integration in the database to compute further pan-European and regional energy system analyses. The ESTMAP project provided the opportunity to review the available public geological subsurface data in the European countries. These encouraging results let open the possibility for further European cooperation in the future.

HOW PRODUCTS OF MAJOR LATE PLEISTOCENE WOODFIRES ON GUAYANA SHIELD (GRAN SABANA REGION) WERE TRANSPORTED TO THE PUERTO RICO TRENCH. DATA FROM CASEIS CORING CAMPAIGN

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Associated to the Lesser Antilles subduction, the Barbados Accretionary complex was built from Late Paleocene to Present. It reached his uncommon size (up to 240 km wide and 15 000 m thick above the subduction front) essentially because of the terrigenous feeding from the South-American continent. During the last decades, these relationships have been demonstrated by different authors through structural, sedimentological, and geochemical surveys, both onshore (Barbados Island and North-eastern Venezuela) and offshore. Detailed surveys dedicated to the present day processes involved in the prism activity, underlined a major link with the drainage of the north-eastern Guyana Shield towards South Atlantic. Based on detailed bathymetry, seismic reflexion, coring, and modelling, Deville et al. (2015, and references therein) underlined a major feeding from the Orinocco Delta. This distribution implies the combination of oceanic bottom current and a complex system of canyons, and relays of piggy-back basins. The deepest circulation follows the deformation front of the prism and/or the foot of the oceanic ridges converging towards the Lesser Antilles subduction.

During the CASEIS Campaign (May/July 2016, DOI 10.17600/16001800) on board R/V POURQUOI PAS? the northern half of the Lesser Antilles forearc realm, including the Barbados Accretionary complex, has been surveyed with geophysical imaging, giant piston coring, and box-coring. Different sites were dedicated to intra-prism basins (among them typical piggy-back basins); there, coring penetration was comprised between 9 and 28 m. At the difference, three attempts made in the deepest trough corresponding to the deformation front (at 6500 m depth), failed as the corer could not penetrate more than 1 m. An additional box core retrieved in one of the sites confirms the occurrence of a highly organic layer which prevented penetration. At least 20 cm of vegetal debris and charcoal mixed with clay could be sampled below 40 cm of brown non calcareous mud; this conspicuous layer also contains a coarse terrigenous fraction entirely made of white mica. The vegetal part is made of centimetric wood fragments, leaves fragments and seeds. Although the exact provenance of these components have to be analysed (determination of vegetal genus and/ or species, characterization of the white mica), we tentatively established a correlation of this conspicuous level with the widespread wood fires which transformed a large area of rainforest into the Gran Sabana. Nevertheless, published data concerning the Gran Sabana pointed out a Holocene age for this elimination while our preliminary radiocarbon dating on wood fragments and charcoal yielded respective 20940 ± 140 BP and 19440 ± 110 BP uncalibrated ages. If the same process can be invoked for the abundant material found in our cores, we should consider the main droughts associated to LGM as responsible for the wood fires as it has been demonstrated in other part of the Guyana Shield. The possible complex pathway of this material is discussed.

SEDIMENTARY INFILL AT THE WESTERN TIP OF THE GULF OF CORINTH DURING THE LAST 120 KA: EVIDENCE FOR AN ACCELERATION OF THE SUBSIDENCE

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The Corinth Rift, Greece, is a young and active continental rift stretching over150 km between the cities of Patras and Athens, and is partly covered by the sea forming the Gulf of Corinth. The present study is focused on the western tip of the Gulf, west of the town of Aigion, where the extension rate measured by GPS is the highest, reaching 14-16 mm/yr. The sediments were investigated using seismic reflection profiling (600 km) to characterize the evolution over the last 120 ka of the sedimentation, subsidence and faulting activity. We combined two lines of evidence, the position of lowstand deltas and isopach maps. The isopach maps were built using two stratigraphic markers could be traced through the seismic grid, the most recent one corresponds to the last post-glacial transgression and the antecedent one to MIS 6 / MIS 5 transgression, at ca. 130 ka. The related isopach maps evidence a spatial change in sedimentary infill along the rift axis probably related to a decrease in activity of the south-dipping faults (i.e. Trizonia/Mornos Faults) that formed the northern edge of the westernmost Corinth Rift in an early stage of the rifting. The different identified lowstand fluvio-deltaic deposits are related to global sea-level lowstands during which the Gulf of Corinth was a lake, whose last reconnection to the Sea occurred around 11.5 ka. Concerning lowstand deltas formed around 11.5 ka, the subsidence rates exceed 3 mm/yr and are maximal under the apex of the Mornos fandelta (5.0-6.6 mm/yr) and in the hanging wall of the north-dipping Lambiri fault (5.9-7.5 mm/yr). Regarding the anterior lowstand delta, the subsidence was lower ranging from 1 to 2.7 mm/yr. These changes would arise because of the northward migration of the strain toward the north, e.g. the Marathias fault.

MAJOR CONTROL OF AUTOGENIC PROCESSES ON PERITIDAL AND SUBTIDAL CYCLICITY IN LOWER PLIENSBACHIAN ORIENTAL TRARAS MOUNTAINS, ALGERIA NORTHWEST

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Meter-scale shallowing-upward cycles are recorded in different carbonate successions around the world. Nevertheless, the debate on their generating mechanisms: autocyclic, relating to intrinsic controls, allocyclic, resulting from orbital forcing and tectonic movement, or both, is still open. Such cyclicity is recognized in the lower Pliensbachian of two outcrops belonging to Traras Mountains, in the North-West of Algeria. The detailed sedimentological study is based on six sections logged in the both outcrops: Annina Boudjellil and Dahr Diss. It allowed to distinguish 25 lithofacies, grouped into nine facies association, ranging from inter-supratidal to shallow subtidal environment. A subtidal cyclicity is depicted in the Annina Boudjellil outcrop. It is formed by an oncoidal rudstone within peloidal-ooidal packstone, developed in a lagoonal environment with open circulation. It alternates with a poorly sorted ooidal grainstone, indicating the transition between a shoal and distal lagoon, or well-sorted oolite, representing a shoal deposit. The cycles show varying thicknesses and are not correlatable even at a short distance within the same outcrop. They are therefore interpreted as induced principally by autocyclic processes, generated by lateral migration of shoal upon lagoonal environmental deposits, above the fair weather wave base. This lateral progradation is proposed to have been controlled by tidal or storm currents, which enhanced sporadic and episodic migration of the shoal upon the lagoon, resulting in randomly-distributed shallowing-upward sequences. In the oriental part of the Dahr Diss outcrop, a shallowing-upward peritidal cyclicity is recognized. It consists of subtidal lagoonal deposits, developed in a narrow depression inherited from the Paleozoic topography, passing up gradually to fine-grained tidal flats deposits. This cyclicity could be related to an autocyclic processes as well. It results from the progradation of tidal flats over the lagoonal facies deposits. Further lateral progradation of the tidal flats was rapidly blocked by the Paleozoic devonian substrate, which bordered the small depression. In the proposed reconstruction, they started to prograde towards the subtidal milieu, filling up the accommodation space. A new cycle began when a new accommodation space created by a constant subsidence rate. This model, originally developed by Ginsberg, 1971, finds support in our observations from the studied area. These peritidal cycles reveal episodes of shortlived exposure at the top of each cycle. They lack supratidal deposits over their subtidal portions, which allows us to exclude a possible sea level drop. In addition, these cycles are not correlatable, and do not appear in other sectors of Traras Mountains. This allows us to attribute their origin to autocyclic, rather than allocyclic, controls. Allocyclic controls are not completely discounted, but are suggested to have exerted a minor eect on the formation of the studied succession.

CLAYS DISTRIBUTION AND RESERVOIR QUALITY OF ORDOVICIAN SANDSTONES IN SOUTH TUNISIA

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In Tunisia, Ordovician silicoclastic deposits are found in subsurface in two basins in the South: Ghadames Basin and Chotts' Basin which are separated by Telemzane Arch. They comprise proven sandstone reservoirsquartz arenitenotably the oil-bearing Bir Ben Tartar Formation in Ghadames Basin, the oil-and gas-bearing Hamra Formation and the recent oil discovery of El Atchane Formation in Chotts' Basin. The most relevant diagenetic processes and reservoir quality are essentially controlled by clays which can be grain-coating (early diagenesis) or pore-filling (late diagenesis) and may respectively preserve original porosity or reduce it.

Sedimentological, mineralogical and petrophysical studies, consisting in core logging, microfacies, SEM (Scanning Electron Microscopy) and XRD (X-Ray Diffraction) analyses, in addition to routine core analyses (He-porosity, horizontal air-permeability and grain density) were undertaken to determine the different facies types and their relative petrophysical properties and to define the different Rock-Types with consideration of matrix properties and particularly clay content and distribution.

In Ghadames Basin, Bir Ben Tartar Formation corresponds to lower shoreface to offshore setting. The sandstones are burrowed and bioturbated with variable percentages of kaolinite, illite and chlorite/chamosite. Some layers are very rich in pore-lining chlorite which prevents quartz-overgrowth and preserves so the original porosity. This facies constitute the best rock-type and is difficult to characterize by well logs as reservoir. Indeed, it corresponds to low resistivity pays on logs as chlorite contains iron; or generally oil-rich layers correspond rather to high resistivity intervals. This facies comprises also occasional kaolinite and illite within pores.

In Chotts' Basin, Hamra sandstones correspond to upper shoreface and the underlying El Atchane Formation is lower shoreface. In Hamra formation, the Skolithos-rich facies are considerably poor in clays and have reservoir quality worse than the associated structureless, probably originally bioturbated facies. In these two formations, the most common clays are authigenic kaolinite and illite. Illite was proven to be grain-coating preventing quartz-overgrowth and it was also determined within the intergranular pore-space. Similarly, vermicular and book-like kaolinite/dickite occur commonly as discrete aggregates filling pores and reducing pore-throat size and permeability.

Comparing chlorite-and illite-grain-coating, the latest looks less effective in preserving primary intergranular porosity. In fact, in Chotts' Basin wells, Ordovician sandstones present partially to totally illite-coated quartz grains and are generally tight. However, the chlorite-rich sandstones of Ghadames Basin exhibit well coated grains and are highly porous and permeable; some layers even correspond to loose sandstones with almost 20% of chlorite. Early diagenesis and burial processes, in addition to the structural difference between clays which determines the surface area exposed to reservoir fluids, induce this divergence in reservoir quality. Besides, microporosity related to clays must be carefully considered in reservoir assessment, particularly for effective porosity and water saturation calculation. Ordovician reservoirs are different in Ghadames and Chotts' basins. Predicting the facies types and the clays which are most likely to develop, then understanding the diagenetic history, the clays distribution and their impact on the reservoir quality allows Rock-Types ranking and selecting the best layers to produce hydrocarbons.

THE PERMIAN-TRIASSIC TRANSITION AND THE BEGINNING OF THE MESOZOIC SEDIMENTATION OF HIGH ATLAS OF MARRAKECH AND ARGANA BASINS: ATTEMPT OF CORRELATION AT WESTERN PERI-TETHYAN DOMAIN

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The Permian-Triassic Boundary is an important interval, intensely studied to clarify climatic, biotic and environmental conditions. Continental sedimentation of the studied interval, upper F2/F3/lower F4 and upper T2/T3/lower T4 units, respectively in the High Atlas of Marrakech and Argana Valley spans from late Permian, dated from vertebrates, to Middle Triassic. It records all changes in the depositional environments under tectonic and climatic control. The sedimentological study aimed to characterize the Permian-Triassic transition by a sedimentological outcrop analysis, to recognize sedimentary facies, facies associations, to reconstitute the depositional history and the palaeogeography evolution from the end of the Permian to the beginning of the Triassic siliciclastic succession. Finally, from depositional sequences we propose stratigraphic correlation at the scale of Morocco basins and the western Peri-Tethyan domain. The late Permian (upper F2/upper T2 units) facies association represents fluvial fans in a dry alluvial plain. The Early Triassic F3 /T3, dated from food prints, and F4a/T4a units rest unconformably on the Permian strata, and consist of (i) arid alluvial fans, (ii) aeolian deposits, (iii) palustrine-lacustrine deposits, (iv) floodplain, (v) meandering river and (vi) braided river. The Anisian F4b/T4b units represent axial fluvial plain of high sinuosity rivers. The dynamics of alluvial fan, fluvio-lacustrine, eolian deposits, the synsedimentary tectonic and the baselevel fluctuations will be taken into consideration during the filling of the sedimentary basins to constrain the stratigraphic cycles. The evolution of early Triassic environments constitutes a major stratigraphic cycle with retrogradational and progradational trends, and is bounded by surfaces correlated at the scale of Morocco basins. The Anisian units are characterized by floodplain and meandering river deposits, and represent the beginning of another stratigraphic cycle. The stratigraphic cycle can be discussed at the scale of western Peri-Tethyan domain.

ON THE MICROSTRUCTURE, GROWTH PATTERN, ORIGINAL POROSITY AND DIAGENESIS OF BELEMNITE ROSTRA: IMPLICATIONS FOR INTERPRETING THEIR GEOCHEMICAL ANALYSES

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Calcitic belemnite rostra are usually employed to perform paleoenvironmental studies based on geochemical data because it is generally accepted that they retain their original microstructure, mineralogy and geochemical composition and are relatively stable and resistant to diagenetic alteration. However, several questions, such as their original porosity and microstructure, remain open, although these questions are essential to make accurate interpretations based on geochemical analyses.

This work revisits and enlightens some of these questions based on detailed petrographic analyses of well-preserved Jurassic belemnite rostra and elemental geochemical analyses. Petrographic data demonstrate that calcite crystals of the rostrum solidum of belemnites grow from spherulites that successively develop along the apical line, resulting in a “regular spherulithic prismatic” microstructure. Radially arranged calcite crystals emerge and diverge from the spherulites: towards the apex, crystals grow until a new spherulite is formed; towards the external walls of the rostrum, the crystals become progressively bigger and prismatic. Adjacent crystals slightly vary in their c-axis orientation, resulting in undulose extinction, which is typical of belemnite rostra.

Petrographic observations also reveal that, as previously suggested by other authors, the growth of the belemnite rostra was not continuous. Concentric growth layering develops at different scales from around 1 mm to dozens of microns, which is enhanced under epifluorescence microscopy. Concentric pattern is superimposed and traversed by a radial pattern, which results in the micro-fibrous texture that is observed in the calcite crystals in the rostra. In detail, radial micro-fibrous sectors change their shape and width as successive concentric layers are formed.

Moreover, petrographic data demonstrate that single calcite crystals in the rostra have a composite nature, which strongly suggests that the crystals formed during two different growth stages and that the belemnite rostra were originally porous. Single crystals consistently comprise two distinct zones or sectors in optical continuity: i) the inner zone is fluorescent and has relatively low optical relief under transmitted light (TL) microscopy, a dark-grey color under backscatter electron microscopy (BSEM), a commonly triangular shape, a “patchy” appearance, relatively high Mg, Na, and S contents and very low Fe and Mn contents; ii) the outer sector is non-fluorescent and has relatively high optical relief under TL, a light-grey color under BSEM, low Mg, Na and S contents and very low Fe and Mn contents. The inner and fluorescent sectors are interpreted to have formed first as a product of biologically controlled mineralization during belemnite skeletal growth and the non-fluorescent outer sectors as overgrowths of the former, filling the intra-and intercrystalline porosity during early to late diagenesis. The petrographic features of composite calcite crystals in the rostra also suggest nonclassical mineralization of belemnites, as previously suggested by other authors.

Accepting that belemnite rostra were originally porous has important implications for making paleoenvironmental and/or paleoclimatic interpretations based on geochemical and isotopic analyses of belemnite rostra, because in order to make accurate interpretations researchers should take care and be able to confirm the diagenetic environment under which calcite overgrowths precipitated.

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SINUOSITY-CONTROLLED DEPOSITION ALONG A CHANNEL-LEVEE SYSTEM AT THE MIDDLE BENGAL FAN – A HIGH-RESOLUTION STUDY INTEGRATING SEISMOACOUSTIC AND IODP EXPEDITION 354 DATA

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The Bengal Fan-Himalaya source-to-Sink system provides the most complete sedimentary record of the erosional, tectonic and climate history of the area, covering the time from fan initiation in the early Eocene to present. Almost 80% of the eroded material from the Himalayan Mountains is stored in the Bengal Fan. In the modern situation, the sediment is transported from the Himalayan Mountains to the Bengal Shelf via the major rivers Ganges and Brahmaputra and further to the deep sea via episodically occurring turbidity currents. Since the Late Miocene, these turbidity currents construct channel-levee systems on their way downslope, which now represent the main architectural element of the Bengal Fan. Frequent channel avulsions but also reoccupation of older pathways resulted in a complex erosional/depositional system with lateral depocenter migration over the entire fan.

Here we present results from an integrated study of a net of (very) high-resolution sediment echosounder (Parasound) profiles and IODP Expedition 354 drilling results, investigating the latest active channel-levee system at the middle Bengal Fan (8° N). The active channel-levee system acts as the main transport pathway of sediments from the shelf to the Bengal Fan during deglacial sea level rise and Holocene high stand. This study focuses on the assessment of spatial and temporal changes in deposition along the active channel-levee system, the relationship between channel sinuosity and overspill depositional patterns as well as the determination of mass accumulation rates to provide constrains for the quantification of sedimentary fluxes and its spatial variability.

The levee could be divided into 3 main phases of overspill deposition by turbidity currents and two phases of mainly hemipelagic deposition during times of either reduced channel-activity or complete shut-off of the system. Average sedimentation rates, determined based on radiocarbon dating, allowed the establishment of a preliminary stratigraphy for the active channel-levee system at 8°N. The onset of overspill deposition occurred around ~28 ka BP and was interrupted at ~25 ka BP for almost 10 kyrs until 15 ka BP. Following this time of inactivity, turbiditic deposition was reactivated for another ~5 kyrs. At ~10 ka BP, the active phase of overspilling, at least at 8° N finally stopped and the deposition of a calcareous clay drape started.

Thickness and geometry of the individual levee units revealed a strong influence of channel sinuosity on the overspilling deposition. Vice versa, the external geometry and thickness of the levee units provide a strong tool to reconstruct former meander-bend positions. The mass accumulation of the investigated time slices however is relatively constant despite the locally uneven and patchy deposition. Sedimentary fluxes appeared to be relatively uniform throughout the channel lifetime.

This study emphasizes the influence of channel sinuosity on deposition in the Bengal Fan as well as for other submarine fans. It also shows that a sufficient long-time average must be used when determining sediment budgets. Where no multiple coverage of a channel-levee system is available, budgets should be averaged over the entire lifetime of one system in order to minimize statistical errors generated by short-term fluctuations.

GEOLOGICAL RECONSTRUCTION OF THE SEDIMENTARY SUCCESSION IN THE BONIFACIO STRAIT (CORSICA-SARDINIA, CENTRAL MEDITERRANEAN SEA): INSIGHTS FROM THE RE-PROCESSING OF AN EXISTING SEISMIC LINE (CROP LINE M-2A/I)

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Major scientific projects of the past provided rich geophysical databases that have been studied in the years following their acquisition and, later, have been partly left behind. One of these examples is represented by the Italian deep crust geophysical exploration project (the CROP Project) that has allowed to acquire and gather a large amount of geophysical data (seismic, gravimetric and magnetic), that have been intensely studied in for several years. Notwithstanding this commendable work, an enhancement of our knowledge of the geology (in terms of sedimentary basins and tectonic evolution) in the Mediterranean region using the CROP Project data can still be possible, as geophysical and geological techniques, such as processing and interpretation, improve. In particular, the CROP reflection seismic data, acquired to investigate the deep crust, provides the opportunity to study in greater detail the shallower part of the Earth crust by a re-processing of the original field data.

In this study we focus our attention on the M-2A/I profile, a segment 100 km long of the M-2A line, acquired in the Bonifacio straits area between the Corsica and Sardinia Islands, along a roughly E-W oriented trace. A dedicated processing sequence has been applied to the M-2A/I profile seismic data for two-way traveltime (TWT) less than 3-4 s.

Reprocessing was limited to the pre-stack time migrated image. The main problems we found were due to the acquisition parameters that were optimized for deep exploration: the spread employed, for instance, resulted in an actual low value for the fold coverage at very shallow-depth and the bandwidth used in a limited resolution for the shallow targets we are interested in. Moreover, the attenuation of the multiple reflections, in particular the sea-bottom multiple, was hampered by the interference of the source wavelet with the sea-bottom primary reflection especially for shallow sea depth. Another issue is that the profile was not acquired along an actual straight line and only the source coordinates are available. Due to the lack of receiver coordinates we had to resort to a nominal 2D profile.

The re-processed seismic lines was interpreted after a detailed study of the units cropping out along the coast of Southern Corsica and Northern Sardinia. Regional geology and the geometry of the reflectors in the re-processed lines allowed the interpretation of the seismic line in terms of geological units. The interpretation suggests the presence of a Mesozoic succession, previously undescribed, in the Balearic side of the Corso-Sardinia block, gradually onlapping the Variscan basement (granites and metamorphic rocks) toward the east. The Mesozoic succession is unconformably covered by Cenozoic (mostly Oligocene and Miocene) units, according to the constraints from the outcrops preserved north and south of the seismic line. Tectonic activity is mostly recorded by strike slip faults (identified according to the geometry of the interpreted fault planes), frequently with a transtensional component.

This approach demonstrates the potential contribution of the re-processing of existing seismic lines with different strategies and new tools, in order to improve the geological knowledge of complex sedimentary basins.

ONCOIDAL AND NODULAR CARBONATES IN A SILICICLASTIC-DOMINATED FAULT-CONTROLLED CONTINENTAL BASIN (EARLY PERMIAN, NORTHERN ITALY): GENETIC PROCESSES AND ENVIRONMENTAL CONTROL

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Fault-controlled extensional basins in continental settings can store a wide range of deposits due to the interplay of numerous factors, such as tectonics, inherited topography, depositional mechanisms, sediment supply and climate conditions. When these basins are endorheic, perennial lakes (in case of high precipitations) or ephemeral ponds (in case of semi-arid conditions) can develop and carbonate deposits (either extensive or limited) can occur: structures, geometry and texture of these deposits reflect genetic processes, such as bio-induced precipitation, inorganic precipitation, reworking and diagenesis. Carbonates of various types in continental settings can thus be abundant (e.g., synrift presalt succession of the South Atlantic) or rare but, independently from their abundance, the study of the genetic processes is equally important.

In a Permian transtensional basin in the Southern Alps of Italy, two different types of continental carbonates are preserved: oncoidal limestone and carbonate nodules, occurring in a prevalently siliciclastic succession recording distal alluvial fan, floodplain and shallow lake environments. Oncoidal carbonates (a few mm to several cm in diameter) form lenses and beds 5 to about 40 cm thick on average. Interparticle space is commonly filled by carbonate mud, less frequently by volcanoclastic sandstone or clay. Oncoids are typically characterized by two growth styles: a) microbial micrite and b) fibrous calcite. Fibrous calcite appears as clear carbonate crusts. Oncoid growth is characterized by two dominating, almost exclusive processes: one characterized by microbially-induced precipitation, one characterized by fibrous calcite. Sedimentological evidence suggests that oncoids were formed in freshwater shallow ponds or lakes in different climate conditions.

Brownish carbonate nodules typically occur in the basal or middle part of sandstone beds. Alignments of carbonate nodules (up to 30 cm thick and typically up to 30-40 cm long on average) locally evolve to continuous carbonate layers. The carbonate layers ranges in thickness from a few cm to about 50 cm, with frequent variations along bed. Carbonate nodules are frequently characterized by irregular to transitional lateral boundaries, cross-cutting primary depositional sedimentary structures (such as parallel to cross laminations), documenting the post-depositional (diagenetic) origin of the carbonate permeating the sandstone layers.

Texture (at different scale), microfacies types and facies association, as well as stable isotope analyses (C and O) on carbonates confirm that different genetic processes produce oncoids and carbonate nodules. Oncoidal carbonate were deposited in ephemeral shallow lakes, whereas nodules are interpreted as groundwater calcrete, formed at or below the water table in porous sandstone. Subaqueous conditions alternate with subaerial exposures of flat surfaces (as highlighted by frequent mud cracks, vertebrate tracks and raindrop imprints), documenting a semiarid seasonal climate, with periodical development of shallow playa lakes due to events of flooding of the basin floor. Siliciclastic input, deposited as sheet-floods, periodically halted carbonate deposition: laterally persisting carbonate bodies (from a few centimetres to some tens of centimetres thick) were formed in short-lived lakes during periods of reduced siliciclastic input.

Despite their relative abundance, the two recognized genetic processes could produce, in favourable conditions, larger volumes of carbonate deposits in siliciclastic-dominated continental environments.

QUANTIFICATION OF VERTICAL MOVEMENT OF LOW ELEVATION TOPOGRAPHY COMBINING A NEW COMPILATION OF GLOBAL SEA-LEVEL CURVES AND SCATTERED MARINE DEPOSITS (ARMORICAN MASSIF, WESTERN FRANCE)

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A wide range of methods are available to quantify Earth's surface vertical movements but most of these methods cannot track low amplitude (< 1 km, e.g. thermochronology) or old (> 5 Ma, e.g. cosmogenic isotope studies) vertical movements where deformation is damped. The difference between the present-day elevation of ancient sea-level markers (deduced from well dated marine deposits corrected from their bathymetry of deposition) and a global sea-level (GSL) curve are sometimes used to estimate these vertical movements. Here, we formalized this method by re-assessing the reliability of published GSL curves to build a composite curve that combines the most reliable ones at each stage, based on the potential bias and uncertainties inherent to each curve. We suggest i) that curves which reflect ocean basin volume changes are suitable for the ca. 100 to 35 Ma "greenhouse" period ii) whereas curves that reflects ocean water volume changes are better suited for the ca. 35 to 0 Ma "icehouse" interval and iii) that, for these respective periods, the fit is best when using curves that accounts for both volume changes. We used this composite GSL curve to investigate the poorly constrained Paleogene to Neogene vertical motions of the Armorican Massif (western France). It is characterized by a low elevation topography, a Variscan basement with numerous well dated Cenozoic marine deposits scattered upon it. Using our method, we identify low amplitude vertical movements ranging from 66 m of subsidence to 89 m of uplift over that time period. Their spatial distribution argues for a preferred scale of deformation at medium wavelengths (i.e., order 100 km), which we relate to the deformation history of northwestern European lithosphere in three distinct episodes: i) a phase of no deformation between 38 and 34 Ma, that has been previously recognized at the scale of northwestern Europe, ii) a phase of low subsidence between 30 and 3.6 Ma, possibly related to buckling of the lithosphere and iii) a phase of more pronounced uplift between 2.6 Ma and present, which we relate to the acceleration of the Africa-Apulia convergence or to enhanced erosion in the rapidly cooling climate of the Pleistocene.

CENOZOIC DEFORMATION TIMING AND REGIME OF THE ARMORICAN MASSIF (WESTERN FRANCE): NEW INSIGHTS FROM A REPROCESSED HIGH RESOLUTION SEISMIC PROFILE (RENNES BASIN)

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The Armorican Massif is one of numerous Variscan basement blocks of Western Europe characterized by low to moderate elevation plateaus (e.g. Massif Central, Rhenish Massif) which have experienced several episodes of burial and exhumation in the Mesozoic and/or Cenozoic. This massif was twice buried then exhumed between Jurassic and Paleocene times in response to relative movements between Iberia and Eurasia. However, as other western European shields, its Paleogene to Neogene deformation history is still poorly constrained despite the presence of numerous Cenozoic (Ypresian to Piacenzian; 56-2.6 Ma) lacustrine to shallow marine deposits scattered upon it. Some of these deposits, mainly the Bartonian to Rupelian (41-28 Ma) ones, are preserved in small narrow grabens bounded by N140E faults. The Rennes Basin, a 2 to 4 km width for 400 m depth basin, is the largest and well-documented one with: i) a well-dated borehole which cross the whole Bartonian to Piacenzian series and reach the underlying basement (CDB1 Borehole, CINERGY Project, 2010); ii) a 5-km long high resolution seismic reflection profile which cut across the basin (HR1 profile, GeoFrance 3D program, 2000 – reprocessed in 2012).

Here, we investigate this reprocessed seismic profile to bring new constraints about the Cenozoic deformation history of the Armoricain Massif. We converted the CDB1 borehole into seismic velocity and some shallow seismic reflectors in depth in order to date these reflectors then correlate seismic facies together with sedimentary facies of CDB1 and 58 neighboring shallow boreholes (50 m max.) from the French borehole database (BSS, via Infoterre).

We show that Bartonian to lowermost Rupelian (41-33 Ma) series, which are affected by slight synsedimentary deformation, are gently bended and collapsed between two hidden highly dipping reverse faults. These faults are subsequently sealed by Lower Rupelian tabular and sparsely faulted deposits. Outcropping Late Langhian to Serravallian (15-11.6 Ma) crags (“faluns”) rest on and overflow these deposits above an angular unconformity (Upper Oligocene – Lower Miocene gap). They are affected by superficial normal faults gently dipping toward the pre-existing weathered basement. The sedimentary succession ends with Pliocene fluvial to estuarine deposits which overlain a second unconformity.

Together with field observations, our results argue for Priabonian (?) to Early Rupelian transtensional to transpressional deformations associated with strike-slip movements along the N140E faults related to a NS tectonic stress. These deformations can be integrated within the Western European tectonic framework. They are likely to be related to the growth of numerous small sedimentary basins during Oligocene to middle Miocene times (ca. 35 – 10 Ma) along the western side of the British Isles (e.g. Cornwall) in a largely strikeslip regime, which led to local basin inversions. They also coeval with Oligocene (Eocene?) to Miocene short-wavelength deformation observed in surrounding basins and on the northwestern European platform that includes strike-slip to compressive folding (South Armorican Margin), major basin inversion (Western Approaches Basin) and NNE-SSW striking left-lateral transtensional wrenching of the European Cenozoic Rift System.

CARBONATE PLATFORM SLOPES: THE IMPORTANCE OF CONTOUR CURRENTS

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The major carbonate platforms lie in zones of the ocean with vigorous currents, either driven by winds or as part of the global ocean current system. Carbonate platforms form rigid obstacles for the flow of such currents, and the water stream is deviated and accelerated when it impinges on the flanks of the buildups. This has consequences for the sedimentation, the facies distribution, and the stratigraphic packaging along the slopes of carbonate platforms. Examples for such current dominated carbonate platform slopes among others are provided by the Great Bahama Bank and the atolls of the Maldives. Using sedimentological and geophysical data, these cases will be used to show the different effects of currents on platform slope deposition. Whereas the windward or leeward exposure of the flanks of such carbonate platforms is the major factor controlling the potential amount of sediment which can be distributed along the slope, sedimentation is dictated by the current regime. Sediment depocenters are directly linked to the flank exposure to contour currents, with greater sediment thickness in current-protected zones. The winnowing effect of contour currents also results in unexpected trends of basinward coarsening grain-sizes, and with elevated flow velocities, toe of slope erosion develops. Slope winnowing, sediment reworking and erosion by drift currents finally may be strong enough to suppress sediment deposition at the slopes of carbonate platforms during sea level highstands. We propose that the action of contour currents on carbonate platform slope deposition and stratigraphy should be taken into account as a possible and even major controlling factor when interpreting carbonate platform outcrop and subsurface data.

RESTRICTION AND DOLOMITIZATION OF HINTERLAND CARBONATE PLATFORMS: INSIGHTS FROM MG ISOTOPES IN A MULTIPROXY APPROACH OF THE PROXIMAL EDGE OF THE LEVANT ALBIAN PLATFORM, ISRAEL

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A combination of environmental and geological conditions makes carbonate platforms highly susceptible to dolomitization. This susceptibility stems from the geometry and internal architecture of carbonate platforms, which are in turn controlled by the size and depth of the water bodies where carboantes were formed. Shallow water bodies have the potential to generate limited lateral exchange conditions by sequential gateways, shoals and reefs between proximal intrabasins and the open ocean. This restriction promotes the formation of modified solutions in the internal intrabasins, particularly in arid environments.

The Albian Levant platform in Israel is characterized by epicontinental conditions in which the sedimentary sequence is extensively dolomitized without depsotion of significant mass of evaporites. The platform had only experienced shallow burial conditions and significant orogenic or magmatic episodes that may influence the geochemical signals are negligible. Such conditions of the Albian Levant platform carbonates provide an opportunity to evaluate the local basinal overprint and the relation to the dolomitization condition.

Based on detailed sedimentological, petrophysical and geochemical analyses, the Late Albian platform sequence (Heviyon Fm.) can be divided into three distinct units: a lower intercalating calcite/dolomite unit that shallows upward with high amount of metazoans and large Ca-dolomite crystals; a middle dolomitic shallowing-upwards-unit with multiple exposure events and stromatolites, further characterized by small Mg-dolomite crystals; and an upper calcite deepening-upwards-unit with a drowning surface at its top and characterized by large Ca-dolomite crystals.

The detrital-free dolomite strata have a $^{87}Sr/^{86}Sr$ range of 0.707466±0.000096 (n=8), which is comparable with coeval seawater values. This, in combination with fine dolomite crystal sizes (17±18 µm), well preserved sedimentary textures in the dolomite, particularly in the stromatolites, indicate early to concurrent dolomitization. The dolomite has relative uniform $\delta^{13}C$ values of 0.59±1.57‰, and high Mn content, as well as elevated Ni/Co, V/Cr ratios, which point to suboxic conditions during the formation of the dolomite, where dolomitization appears to be primarily of microbial origin, with a contribution from elevated salinity. The $\delta^{26}Mg$ values of dolomite however, increase from a uniform value of -1.99±0.12‰ (n=10) in the lower part of the sequence to a value of -1.52±0.02‰ (n=30) in the middle interval, after which $\delta^{26}Mg$ values decrease back to -2.06±0.18‰ (n=5) in the upper unit. This shift is coupled with changes in Mg content of the dolomite crystals (r=0.54; n=51), suggesting connection with chemistry of the parent solution. Given the mode and timing of dolomitization, as well as the trend of the change, this Mg isotopic variability appears to be the product of syn-depositional changes in water chemistry as a result of restriction and rejuvenation of the intrabasinal waters during calcification and dolomitization. The case of the Albian Levant platform shows that Mg isotopes are a powerful tool for tracing of the evolution of carbonate depositional environment, and notably of dolomitizing fluids in carbonate platforms.

DIGITAL OUTCROP MODELING USING "STRUCTURE-FROM-MOTION" PHOTOGRAMMETRY: APPLICATIONS TO ANALYZE NEOGENE–QUATERNARY ENVIRONMENTAL SIGNALS PRESERVED IN THE ANDEAN FORELAND, ARGENTINA

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In the last years, the progressive technological and geomatic revolution made it possible to obtain digital outcrop models (DOM) and high-resolution digital terrain models (DTMs), using a novel photogrammetric technique named "Structure from Motion–Multi-View Stereo (SfM-MVS)". This photogrammetric method produces 3D point clouds or mesh models using multiple overlapping offset images. The major success of this technique is that allows constructing 3D models similar that obtained with more sophisticate techniques (e.g., LIDAR, Terrestrial Laser Scanning), although with a greatly enhanced ease-of-use and the advantage of being low-cost. A typical complete workflow to develop this technique involves: (i) field work component to establish ground control points and acquire the photoset, either taking terrestrial photos or using unnamed aerial vehicle; (ii) a computer processing for the 3-D scene reconstruction; (iii) a post-processing stage to scale and geo-reference the model; and (iv) a 3D analysis using a 3D visualization & interpretation software for geological data (e.g. VRGS ®). The objective of this work is to illustrate the effectiveness of the SfM-MVS technique for the resolution of quantitative case studies devised in the context of sedimentary systems influenced by tectonics and climate changes.

Two case studies located in the Southern Andean Foreland, Argentina, previously analyzed with traditional fieldwork, were selected and re-analyzed. For each case study the aim was to solve questions that were not possible to carry out without the using of DOM and DTMs, such as: (a) determining of tilting phases related to contractional tectonic deformation based on the analysis of progressive discordances in the Neogene infill of the Andean Foreland (i.e. Piedra del Aguila Basin); and (b) the quantification of lake level fall during the past 10 years of a closed basin evaluating the geomorphological impact over the exposure landforms (i.e., the Laguna Carri Laufquen Grande in the Maquinchao Basin). Related to the first case, the results suggest that four deformation phases occurred, two of them involving a inter-tectonic sedimentation and the others syn-tectonic sedimentation. In addition, the analysis of progressive discordances allows to establish different tilting phases. The accurate statistical analysis of strike and dip directions determined variations of the tilting axis, which were related to different scale of structures, such as local fault-propagation fold and regional rotation of fault blocks. Related to the second case, the analysis and interpretation of the DEMs and satellite images of the last decade (i.e., 2002-2016) allow to constrain the ages and topographic position of the different modern lake shorelines, showing lake level variations up to 8.5 m. In addition, the analysis of lake level fluctuations together with meteorological dataset of the region suggest that water lake levels have different time of response to climate variations. The outcome of the investigations of this work shows the potential of the SfM-MVS approach to solve cases studies with different spatial and temporal resolution. This increasingly popular technique allows not only to improve the analysis of sedimentary forms, but also to move forward in unanswered questions related to environmental signals preserved in sedimentary systems.

SPATIAL VARIABILITY OF SILICA IN CHALK – USING THE MIDDLE DANIAN DALBYOVER QUARRY AS AN ANALOGUE TO UNDERSTAND 2D RESERVOIR ARCHITECTURE OF SILICA-ENRICHED RESERVOIR UNITS, DANISH BASIN, CHALK GROUP

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Silica has long been recognized to influence reservoir properties in the Danian Ekofisk Formation in the Danish North Sea chalk fields. Recent studies indicate a stratigraphic control on the silica distribution across the Danish Central Graben, with maximum concentrations in the middle Danian. This provides a key tool to improve the predictability of porosity and permeability variations within the Ekofisk Formation in order to improve existing reservoir models and understanding the remaining economic potential of the system.

However, the density of cored wells across the region provides poor spatial resolution of the more detailed architecture of the silica distribution, and its influence on reservoir properties and cementation styles is therefore still poorly understood.

In this study we present detailed sedimentological, ichnological, diagenetic, bulk geochemical and isotope data from the chalk in the Dalbyover Quarry, Northern Jutland. This quarry exposes middle Danian strata corresponding to peak silica horizons identified in the Danish Central Graben.

The quarry displays a chaotic spatial silica distribution on a bed and outcrop scale, which is very different from what is seen in Maastrichtian and Danian chalk outcrops described elsewhere in the Danish Basin. The outcrop is currently believed, based on preliminary results, to form an analogue for offshore silica-enriched intervals in the Ekofisk Formation. An integrated model from the Dalbyover Quarry will thus improve the understanding of small scale 2D reservoir architecture of the Danian Ekofisk Formation.

PARAGENESIS OF SEEP CARBONATES AS RECORDER OF TRANSIENT GAS MIGRATION MECHANISMS THROUGH FRACTURES

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Seep carbonates are the most obvious evidence of methane leakage in the fossil record and they may be used to reconstruct migration mechanisms up to the sea floor. In this perspective, we are going to compare seep carbonates from the Maastrichtian/Danian Moreno Formation outcropping the Panoche Hills, California, deposited in a forearc basin setting, and the seep carbonates of the Pliocene Yenshuikeng Shale Formation, outcropping in the exhumed accretionary prism of Taiwan.

Seep carbonates of the Panoche Hills consist of blobby concretions, a few meters in diameter, developed at the tip of sand dykes. The injected sand is remobilized from the underlying Panoche Fm., intruded up into the 700 m thick shaly Moreno formation and locally erupted on the paleo sea floor. The $\delta^{13}C$ signature of the carbonates as low as -51 ‰ indicates a biogenic origin for the methane while a 1D thermic model reveals that the lower interval of the Moreno formation, the only known source rock in that area, was in optimal thermal conditions for biogenic gas generation.

Seep carbonates of Taiwan consist of a massive body, up to 15 meters in diameter, locally aligned along faults, evidencing the role of the former as gas migration pathway. The $\delta^{13}C$ of the carbonates as low as -50‰ suggest a biogenic methane origin, although non individualised source rock is clearly identified.

Despite their different geological settings and their different morphologies, both the seep carbonates of the Panoche Hills and from Taiwan exhibit complex but nearly identical early diagenetic features, revealing a common process of methane leakage. The paragenesis, developed in cavities of the seep carbonates bodies, consists of up to 10 repeated elementary sequences, each starting with a corrosion surface followed by dendritic carbonates, botryoidal aragonite, aragonite fans, and finally laminated micrite.

Each element of the sequence is interpreted to reflect three stages. First, a sudden methane pulse extended up into the oxic zone of the sediments, leading to aerobic oxidation of methane and carbonate dissolution. Second, after consumption of the oxygen, anaerobic oxidation of methane coupled with sulfate reduction triggered rapid carbonate precipitation. Third, progressive diminishment of the methane seepage led to the lowering of precipitation rates.

Methane pulses are interpreted to reflect drainage by: successive episodes of hydrofracturing by sand injection into the gas-generating shale of the Moreno Formation, and successive episodes of expulsion of overpressured fluids from the Taiwan accretionary prism through the seismic valve mechanism.

This study highlights the valuable role of seep carbonates as fluid migration mechanisms recorders, ultimately linked to the activity of the underlying petroleum system.

MULTI-SCALE STRUCTURAL AND MORPHOLOGICAL STUDY OF SOUTH CASPIAN MUD VOLCANOES: IMPLICATIONS AND HYPOTHESES ON SOURCES AND FORMATION OF THE MUD

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Mud volcanoes (MV) have been known since the 19th century. Their surface morphologies have been extensively studied but the issue of underground structure and mud generation mechanisms could only be investigated recently with the use of 3-D seismic in particular.

The South Caspian Basin (SCB) and the Lower Kura Basin, onshore Azerbaijan, have the densest known distribution of MV in the world. Three-dimensional (3D) seismic data acquired by oil and gas companies in the offshore domain offer the opportunity to understand possible mechanisms of mud generation and MV systems formation.

The offshore 3-D seismic survey of the Absheron anticline shows two MVs with very different morphologies. The smaller one has a well imaged root system that shows a direct link with the regional source rock, the Maykop Formation. The emplacement of this MV is related to a thrust rooting in the source rock. It creates a truncated small anticline structure as a result of mud expulsion. A rim syncline shows the collapse of strata into the former mud chamber. The extrusion cone is now buried bellow 5 km of sediments. The larger volcano, still active, is located on the anticline crest; its underground structure is poorly imaged due to the presence of gas. Two overpressured intervals are known in the area and could have sourced the mud: the regional source rock (Maykop Fm.) buried at 6.5 km; or the Upper Surakhany Suite at 2.5 km. Seafloor bathymetry shows a 4.5 km-diameter mud shield with 5 mud-pies, 300 m to 1 km in diameter, distributed at its surface. The mud shield is surrounded by a moat and ridge; the latter has been breached on various points and a 10 km long mud flow emanates from the western breach. On seismic sections, compressive structures and other mud flows can be noticed.

Based on a comparison of these MVs with already studied structures of the SCB and field observations of onshore MVs, we propose the following model for the initiation and subsequent evolution of the Absheron MV system. Overpressure accumulates at the crest of anticlines causing pervasive hydrofracturing that propagates upward. Mud forms when the advective column of mixed particles and fluids reaches the seafloor. A higher sedimentation rate or a lowering in fluid advection allows the proto-mud chamber to be buried, slowly increasing mud pressure. The input of fluids into the mud chamber may help to sustain this mud pressure and to decrease mud density. When overpressure is too high or mud is too light, the fluidized material is extruded through a combination of hydrofracturing and passive roof collapse.

This qualitative model will be integrated to a geomechanical model along with results from mechanical measurements on mud samples from the Absheron MV. Other models could be imagined by exploring other possibilities as processes related to clay dehydration. Biostratigraphic analysis of the sediment cores from Absheron will constrain the source of the mud.

IMPACT OF EARLY TOARCIAN ENVIRONMENTAL CHANGES ON NERITIC CARBONATE PRODUCTIVITY AND REEF DEVELOPMENT: NEW INSIGHT FROM THE CENTRAL HIGH ATLAS OF MOROCCO

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Two major environmental changes occurred during the Early Toarcian: the Pliensbachian-Toarcian boundary event and the Toarcian Oceanic Anoxic Event (OAE). These events are responsible for severe floral and faunal turnovers, highlighted for instance by two consecutive second-order ammonite biodiversity crises. This time interval is also characterized by a widespread shutdown of neritic carbonate productivity, often resulting in condensed or hiatal stratigraphic records along the Tethys Ocean, as well as one of the most severe reef crises of the Phanerozoic. Nevertheless, numerous questions remain unanswered about the Early Toarcian carbonate crisis, notably its exact timing, the environmental mechanism causing it, and the tempo and modality of carbonate production and reef recovery. The lack of data about this carbonate shutdown is linked to the common temporal/stratigraphic condensation and large biostratigraphic uncertainties associated with the Toarcian shallow marine sedimentary record. Here we present the first results of a multi-disciplinary study undertaken in the southern part of the Central High Atlas Basin of Morocco where outstanding outcrop exposure, combined with integrated chemo-biostratigraphic controls and expanded sections, allow us to refine our understanding of this topic. To summarize, we can demonstrate that in Morocco, the main episode of neritic carbonate productivity shutdown took place at the Pliensbachian-Toarcian boundary and was linked to an important seawater eutrophication coeval to a transition from an arid to a humid climate. Moreover, there is no evidence for a protracted Toarcian reef crisis in Morocco, although it appears clear that both Pliensbachian-Toarcian boundary and T-OAE events had an impact on reefs and their main constituents. During the late Pliensbachian, both Lithiotid bivalves and corals were significant reef-forming bioconstructors (the former predominantly in lagoonal settings, the latter in uppermost offshore environments). In the earliest Toarcian (pre T-OAE) strata, coral reefs disappear, although corals continued to survive in association with Lithiotid reefs (biostromes); these biostromes continued to thrive in lagoonal settings under elevated water turbidity. Subsequently, the T-OAE corresponds to the demise of the Lithiotid fauna as reefbuilding organisms, though occasional Lithiotid-like bivalves can still be found up to Aalenian strata. The recovery of coral reefs occurred soon after the termination of the T-OAE. The large size of these reefs (up to 100 m wide, 10 m tall) as well as their complex biotic assemblage dominated by large phaceloid corals and microbialites, raises the question as to whether there was a true reef crisis associated with the T-OAE, or if the "reef gap" is linked to preservation issues. It is yet not clear what was the exact cause for the demise of the Lithiotid fauna at the onset of the T-OAE. Biocalcification crisis linked to decreased carbonate saturation state, in addition to the on-going seawater eutrophication, is a potential mechanism that might explain why corals where less impacted than the bivalve guild. Increased hurricane intensity during the T-OAE might also have contributed to the dismantling of the weakened reef structures. To conclude, our study points at a complex response of the neritic carbonate factory and reef builders to the Pliensbachian – Toarcian environmental perturbations.

TEMPORAL CONSTRAINTS ON THE DEVELOPMENT OF URGONIAN-TYPE LIMESTONES IN THE WESTERN TETHYS: NEW INSIGHTS FROM HIGH-RESOLUTION STRONTIUM ISOTOPE STRATIGRAPHY

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Dating uncertainties has so far hampered linking the widespread development of Early Cretaceous Urgonian-type limestones along the western Tethys margin with changes in environmental and oceanographic conditions. This is mostly due to the existence of two conflicting orbitolinid biostratigraphic schemes, which can lead to deviations in age attribution in the order of up to 5 Myr. Despite 30 years of biostratigraphic research, reconciling these two opposing schemes has so far been proven problematic, mostly due to the absence of ammonite findings within Urgonian-type limestones.

In order to shed new light on this challenging question, we have sampled at a high stratigraphical resolution low-Mg calcite rudist shells from a key Urgonian section at Gorges-du-Nan (SE France), where the two distinct orbitolinid biostratigraphic schemes have been previously applied. After thorough diagenetic screening, the best preserved rudists were analysed for their stable strontium isotope composition and the results compared to the high-resolution, ammonite calibrated, marine strontium-isotope curve for the Hauterivian–Aptian interval. Our strontium isotope stratigraphic framework unambiguously demonstrates that the Urgonian limestones exposed at Gorges-du-Nan cover the Late Barremian–earliest Aptian time interval, in strong contradiction to one of the two orbitolinid biostratigraphic schemes postulating that the bulk of Urgonian-type carbonate platform deposition occurred during the Late Hauterivian – Early Barremian. Therefore, our results fundamentally question the validity of the latter orbitolinid scheme.

Based on our new integrated stratigraphic scheme, it appears clear that the development of Urgonian-type limestones in the Vercors area and further north along the northern Tethyan margin was coeval to a period of relatively low nutrient levels and well-oxygenated seawater that might have promoted the development of this photozoan-dominated carbonate factory. Our approach in general, as well as the here presented results in particular, provides a solid fundament for a high-resolution, and temporally well-constrained, shallow-water palaeotemperature study based on rudist oxygen-isotope analysis.

WIDESPREAD METHANE SEEPAGE AND SLOPE DESTABILIZATION IN THE SILESIAN BASIN (OUTER CARPATHIANS) INDUCED BY GAS HYDRATE DISSOCIATION DURING OLIGOCENE

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The Outer Carpathian thrust-and-fold belt is composed of a thick series of siliciclastic sediments, mainly turbidites, Jurassic to Miocene in age. The latest period of deposition was characterized by very high deposition rates during the Oligocene and Miocene. Flysch-type clastic sediments were laid down in a foredeep developed in front of an accretionary wedge. These regular well-bedded sandstones-mudstone alternations are frequently interrupted and topped by chaotic deposits containing various sizes of carbonate blocks. Sedimentological features of these chaotic complexes reveal that the sediments were fluidized and redeposited as submarine slumps. Petrographic and geochemical properties of the carbonate blocks, especially stable C and O isotope composition, indicate that they were formed due to anaerobic oxidation of methane in the source area. Microbial methane was produced in the underlying Eocene-Oligocene organic carbonrich sediments, as evidenced by strongly ^{13}C-enriched (up to 17‰) authigenic dolomites that formed when methanogenesis operated in these sediments. Methane was temporarily bound in hydrates and liberated upon theirdecay. ^{13}C-depleted methane and ^{18}O-enriched water liberated from gas hydrates provided substrates for the seep carbonates. However, the carbonates are composed of mixtures of dolomite and calcite cements and their bulk $\delta^{13}C$ and $\delta^{18}O$ values are not low and high enough, respectively, to unequivocally indicate microbial methane and hydrate-liberated water as their sources. Therefore, we performed a series of experiments with the use GasBench and IRMS that allowed for the estimation of stable C and O compositions selectively for calcite and dolomite cements. These measurements showed that dolomite always exhibits very low $\delta^{13}C$ (between -30 and -45‰) and high $\delta^{18}O$ (between 1 and 2 ‰) values that clearly indicates that dolomite precipiattion was related to the dissociation of gas hydrates. Calcite has variable $\delta^{13}C$ (between -45 and 0‰), which suggests that it is methane-derived only in some samples. $\delta^{18}O$ values of methane-derived calcite are always by 2-3 ‰ lower than those of dolomite in the same samples which suggests that calcite cement, unlike dolomite, did not precipitate from hydrate-released water. Liberation of large quantities of water and methane caused fluidization of the sediments which provoked slumping. The simultaneous slumping in different parts of the basin suggests that slope destabilization occurred on a regional scale and that stability of hydrates must have been regionally disturbed. The cause of regional gas hydrate destabilization was tectonic uplift related to orogenic movements when the accretionary prism was forming. Modeling of P-T conditions in the basin confirms that hydrates could not have been stable in sediments at water depth less than 500 m. This work presents evidence of multiple processes that influenced methane circulation in the sediments, from microbial production, through migration, incorporation into hydrates, liberation to pore water during hydrate dissociation, seepage, to anaerobic oxidation which induced carbonate precipitation. It also shows that even major sedimentary phenomena in the basin evolution, such as widespread slumping, may be related to methane seepage that is recorded in carbonate rocks seemingly exotic to the dominant siliciclastic sedimentation.

LARGE BENTHIC FORAMINIFERA BIOTIC RESPONSE DURING OAE2 : THE GUERRERO-MORELOS CARBONATE PLATFORM, MEXICO

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The Cenomanian-Turonian Oceanic Anoxic Event is well known for the intense and global anoxia in the oceans and the strong carbon cycle perturbation. Numerous and major faunal and flora extinctions occurred during this interval, in particular for large benthic foraminifera. Only few carbonate platforms survived during this crisis like the Guerrero-Morelos carbonate platform (South-western Mexico). The $\delta^{13}C$ curves of the studied sections (Axaxacualco and Barranca del Cañon) exhibit the typical OAE2 features including a large positive excursion. This well preserved carbon isotopic curve recorded in the platform carbonate deposits allows a better understanding of large benthic foraminifera distribution during the OAE2 event and their biotic response to paleoenvironmental changes.

Below the sequence boundary Sb Ce5 (Late Cenomanian) and before $\delta^{13}C$ positive excursion, the microfauna is well diversified, with corals, rudists and large benthic foraminifera as *Pseudorhapydionina chapianensis* and *P. dubia, Cuneolina parva, Dicyclina* sp., and *Chrysalidina gradata* and large miliolids. Above, this faunal association becomes less diversified due to more restricted environment ending with a karstic surface indicative of emersion (Sb Ce5).

Higher up, between the Sb Ce5 and the C/T boundary, which includes the $\delta^{13}C$ positive excursion, the depositional environment is then dominated by high stress condition organisms including ostracods, gastropods, *Istriloculina* sp., *Decastronema* sp., *Thaumatoporella* sp. etc...The endo-benthic assemblage like *Nezzazatinella* sp. and *Nezzazata* sp., are still present, whereas the large miliolids and the large benthic foraminifera probably linked to green symbiotic algae, mostly disappeared except *C. parva* and *Dicyclina* sp.

During the early Turonian, the carbonate platform returned to more open and oxygenated environment, with the reappearance of pre-OAE microfauna, but without the large benthic foraminifera, which did not survive.

The definitive drowning of Guerrero-Morelos carbonate platform takes place in the lower Turonian, well above the end of the $\delta^{13}C$ shift, with the deposition of black shale and turbidites indicating deeper anoxic environments, which preclude large benthic fauna reestablishment.

The detailed analyses performed in the mexican sections, in comparison with the pelagic section of Eastbourne, reveals that despite the different levels of anoxia, a synchronicity of biotic response can be establish between basin and platform environment. Planktonic foraminifera (Eastbourne Basin), benthic foraminifera and algae assemblages (Mexican platforms) reflect alternating depleted and normal oxygen conditions even in very shallow water conditions. Low oxygen conditions are marked by the multiplication of *Heterohelix* species in the basin and coeval with blooms of ?*Decastronema*, *Thaumatoporella* and *Istriloculina* on platforms during the isotopic carbon plateau.

LASCUSTRINE RECORDS IN CORSICA DURING THE LATE HOLOCENE, PALAEOENVIRONMENTAL AND CLIMATIC IMPACT

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Due to this latitudinal position, at the interface between two climatic belts, the western Mediterranean Sea is one of the most sensitive areas to past and present climate fluctuations. The ecosystem subservient to this region is particularly vulnerable to current climate change. The Corsica Island appears therefore a key area for understanding and evaluating climatic and hydrological changes in the Mediterranean Region. A multiproxy approach has been previously applied to reconstruct the last millennial palaeoclimate in Corsica or in nearby areas, as in the sedimentary record in lake in Corsica, in Tuscany and Sicily, the marine sediment records, or in the speleothems records in Italy. However, the lack of other climatic proxies in the last millennial in Corsica is still problematic. In order to better constrain the climatic fluctuation of the last 1000 years in Corsica, it is interesting to investigate the sedimentary records from lakes in Corsica, and in particular the evolution of the geochemical and mineralogical signals. Indeed this approach was not yet performed in this area and can bring useful information about the anthropogenic activity and its evolution especially during the last century.

In this context, preliminary investigations are needed to evaluate the potential sedimentary record in the Corsican lakes, in particular the sedimentary deposition (continuous, gaps, bioturbations, etc.), the deposition thickness, and the time period recorded. Two areas have been investigated: the Nino lake, and the Renoso pozzines which are characterised by high altitude environment (1800-2000 m), but show different types of catchment (size, geology, vegetation) and levels of eutrophication.

Preliminary data based on grain-size analyses, mineralogical analyses (XRD analyses) and geochemical analyses (CHN analyser; Rock Eval; Phosphorus content) show strong and fast fluctuations on the two sedimentary cores, in particular the phosphorus content linked to the eutrophication level. The Nino lake records show strong enrichment in phosphorus, organic carbon and nitrogen contents within the last decimetres of sediments, independent of detritic fluctuations, suggesting an eutrophication probably linked to anthropogenic activity rather than climate changes. Instead of the Renoso pozzines records, which exhibit geochemical fluctuations linked only to detritic fluctuations (climate changes). These data are consistent with biological data based on invertebrate fauna and macrophyte flora studied in these environments.

This study brings some crucial data for the understanding of the recent environment evolution and the anthropogenic impact, which occur in the Mediterranean Sea area.

UPPER APTIAN "TURBID-WATER" CORAL BIOCONSTRUCTIONS: GEOMETRY AND FACIES, LAGA BEACH, BASQUE COUNTRY, SPAIN

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Cretaceous scleractinian corals were not important bioconstructors, mainly because of the marine water chemistry that favoured organisims with a calcitic skeleton, and because of elevated surface temperature. Additionally, oceanic anoxic events and sea-level fluctuations on tethyan seas also influenced coral growth. Nonetheless, the Cretaceous bears key evolutionary steps for scleractinians, such as important replacement of faunas through time, radiation of az-corals, and appearance of certain lineages that gave rise to modern Cenozoic faunas nowadays characteristic of reef ecosystems. Diverse coral faunas have been reported not only from carbonate but also from marly substrates, and some of them even built bioherms and biostromes. During the Early Cretaceous, the Basque-Cantabrian Basin was an epicontinental rift basin with an important siliciclastic input. At Laga beach section, diverse coral biconstructions developed on the distal to middle part of a mixed carbonate-siliciclastic platform. The corals were adapted to turbid environments and mesotrophic conditions with higher sedimentation rates than in oceanic reefs. At the lower part of the section (Otoio Fm; Upper Aptian) diverse bioconstructions, mainly composed by scleractinians, occur in a

20 m thick and 80 m wide outcrop composed of marls. Upwards in the succession, around the Aptian-Albian transition, a Gylbert type delta facies occurs, which represents a shallowing from the coral-bioconstructions inter-val. The bioconstructions were characterized by means of: 1) a 2D stratigraphic cross-section with indication of bioconstructions size (width and height) and of small faults; 2) facies descriptions of each bioconstruction, considering coral morphology (shape), the presence of other taxonomic groups (foraminifera, calcareous algae, sponges and molluscs), and taphonomic features; and 3) presence and relative abundance of coral genera within each bioconstruction. Thirty-eight different bioconstructions were studied, such as associations of centimetre-sized colonies grouped around one or two main larger colonies, or wider tabular bioconstructions of approximately one metre height. There is lateral and vertical heterogeneity in geometry and complexity among the bioconstructions, some of them composed by several facies. Differences were found in the presence and abundance of twenty-five identified coral genera. Geological, sedimentological and palaeontological data are analysed using PCA (Principal Component Analysis). Recent studies on present-day "turbid-water" coral reefs suggest that those ecosystems could be a refuge facing recent climate change. These adaptations could have been also significant during the studied Cretaceous interval.

PREDICTION OF VOLUMETRIC DATA AND RESERVOIR PROPERTIES OF CLASTIC SEDIMENTS OF THE MOZAMBIQUE MARGINS, FROM SEDIMENT SOURCE TO SINK RECONSTRUCTION USING AN EMPIRICAL MODEL AND ANALOGUES

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Sediment supply and potential clastic reservoir parameters are characterized for sandstones offshore Mozambique by reconstruction of sediment source to sink settings. The predicted parameters include solid sediment volume and flux, sandstone porosity, permeability and mineralogy for a welldefined set of palaeodrainages including the Cretaceous Limpopo and the Neogene Zambezi rivers. A complete Earth systems approach was used for reconstruction of the geodynamic framework of the source to sink system, and a newly developed empirical model, the Palaeoflux Model, was used to calculate the volumetric data. Sandstone textural and compositional signatures are predicted through the reconstruction of paleo-tectonic and paleoclimate settings, parent lithology, erosion rates and transport induced modifications. Semi-quantitative porosity and permeability estimates were produced from mineralogical and textural maturity indicators and from comparison with analogues. Volume calculations indicate that a large Cretaceous delta, now buried under the southern Mozambique Plains, was fed by the then very extensive Limpopo River. A solid sediment volume of 1.3 million km^3 was estimated to have been supplied by the Limpopo River to this palaeodelta. Fluctuations in solid sediment flux to the palaeodelta are attributed to intraplate tectonic forcing, drainage readjustments and climate variability. Two significant peaks in sediment supply revealed important phases of deltaic progradation. The maximum flux was equivalent to ~100 million ton per year, three times more than that of the Niger River today. Sandstones were deposited in a variety of delta sub-environments, which in turn controlled sediment textural properties, post-depositional processes (diagenesis) as well as their petrophysical parameters. Sandstone mineralogy within the palaeo-Limpopo Delta varied greatly through time due gradual erosion of Karoo volcanics and increasing exposure of underlying lithologies. Results of the Palaeoflux Model allowed calculating the erosion rate of volcanic lithologies, based on an initial estimated volume and spatial distribution of the Karoo Large Igneous Province. The palaeo-Zambezi River underwent several moderate drainage and flux changes throughout the Cretaceous, but the most pervasive change happened during the Neogene, when the propagation of the East African Rift caused inland expansion of the drainage system. Based on geomorphologic interpretation and newly estimated reactivation ages of separate elements of the southwest branch of the EARS, a thorough revised palaeodrainage evolution was obtained. The solid sediment flux of the palaeo-Zambezi increased five times compared to Paleogene rates, during which the mineral composition of the sediment load also gradually changed. Volumetric and mineralogical results obtained by applying the presented workflow can be used as boundary conditions in reservoir models, petroleum system and basin analysis, global circulation models and Earth system models.

NEOGENE TECTONO-SEDIMENTARY EVOLUTION OF THE NEUQUÉN FORELAND (ARGENTINA)

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On the eastern slope of the Andean chain, the Neuquén Basin is a major producer of oil and gas and it has accounted for about half of the total production of hydrocarbons in Argentina over the last century. In account of this potential, its Mesozoic history is quite well constrained. Because of their weak thickness and bad preservation, the Miocene deposits did not attract much attention. Beyond the lack of economic interest, these deposits are contemporaneous of the last deformation phase in the Andes (the Quechua phase) and could inform on the processes that led to the compartmentalisation of the foreland.

We performed an accurate mapping of the remnants of Miocene deposits at the scale of the whole Neuquén basin and focused on the sedimentological characterisation to document the sedimentary pro-cesses that led to the filling and excavation of intramountain basins. From a cartographic approach coupled with a dating of detritical zircons, we aim to build a regional chronostratigraphic synthesis to more particularly document the relative chronology of tectono-magmatic events and their impact on sedimentary transfers. Our objective is to propose a paleogeographical reconstruction.

This work in progress already allows identification of three main sediment transfer systems from the mountain interior to the foreland. They approximately correspond, from north to south, to the current catchments of the Rio Colorado, Rio Neuquén and Rio Limay Rivers. In detail during the Neogene, these fluvial systems have been disturbed by uprising of tectonic dams.

At the regional scale, two major trends compartmentalized the basins: one North-South corresponds to the forward migration of the Andean tectonic front; one East-West is underlined by the well known Mesozoic Huincul Ridge and by the more hypothetic Cortaderas and Rio Limay Lineaments. This suggests that these sparse deposits could be good markers of vertical crustal movements since the Neogene.

DRAINAGE REORGANIZATION EXPLAINS THE LARGE-SCALE FAN-SHAPE MORPHOLOGY OF THE NORTHERN PYRENEAN LANDSCAPE: NO MEGAFAN IN THE NORTHERN PYRENEAN FORELAND

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On the Northern side of the Pyrenees, the morphology of the foreland corresponds to a piedmont which is currently eroded by rivers belonging to the Garonne and Adour drainage basins. A particularity of this network of rivers is to show a regional divergent pattern at the scale of the piedmont, from a source area located at the mountain-piedmont transition, at mid-distance between the Mediterranee and the Atlantic Ocean. The radial drainage network is closely associated with a large-scale fan-shape topography of the whole piedmont (radius > 100 km, height ~500 m). Some recent studies proposed that this regional-scale fan-shape is the consequence of a recent localized differential uplift of the piedmont, or that it resulted primarily from recent deposition in a unique large alluvial fan, the megafan of Lannemezan. Here, we show that none interpretation is satisfying and we use numerical simulations of surface processes (numerical code CIDRE) to propose an alternative model for explaining this particular landscape of the northern Pyrenean piedmont. We show that it likely results from successive steps of drainage reorganization, primarily linked to the geometry of boundary conditions for erosion. Our simulations successively reproduce most morphological observations and characteristics of the northern Pyrenean landscape. Then, we show that no recent deformation of the piedmont needs to be invoked to explain its morphology and that there is not any megafan on the northern flank of the Pyrenees.

ON THE RECORD OF EROSION AND INCISION DYNAMICS BY OSL DATA FROM FLUVIAL TERRACES (RANGITIKEI RIVER, NEW ZEALAND)

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Landscape response to climate induces periods of enhanced sediment supply to rivers promoting the formation of climatic-aggradation fluvial terraces whose age and height are used for estimating mean fluvial incision rates. These rates must however be taken with caution. Numerical simulations actually suggest that incision rates are not linear between the formation of two successive terraces.

The Rangitikei River (New Zealand) is downcutting in an uplifting basement. Entrenchment is punctuated by terraces, the more recent one (T1) being classically considered to formed from 30 to 15 ka. Since abandonment of T1, the river incised 75-meter deep gorges within the bedrock. We investigated this entrenchment using Optical Stimulated Luminescence dating (OSL, here IRSL on feldspars) of 17 alluvial deposits from strath terraces cuting to the bedrock. We performed measurements using Multiple Aliquots or Single Aliquot Regenerative protocols on large aliquots of fine grains of feldspars (4-11 µm) as well as measurements on single-grains on a coarser fraction (125-200 µm) of the same samples but using Post-Infrared IRSL (p-IRIR) protocol.

We show that:

(i) abandonment of terrace T1 occurred ~10 kyr ago, more recently than previous estimates

(ii) a period of very fast incision follows the formation of T1. Incision rate then slows down; this decrease coincides with the development of extensive post-T1 terraces. Our data support numerical findings showing that the ratio of vertical incision to lateral planation is driven largely by variations in vertical incision rate

(iii) The distribution of single-grains ages depends on the river incision rate, periods of fast incision being characterized by a larger proportion of unbleached grains in the samples. Accordingly, IRSL ages obtained using classical methods that consider measures on aliquots instead of on singles grains, all show an overestimation of ages whose magnitude depends on incision rate.

We show that in p-IRIR geochronology, the proportion of mixing between bleached and unbleached grains is intimately linked to variations in the rate of bedrock erosion and related supply of unbleached grains to the river. Our study consequently suggests that the shape and width of IRSL age distributions obtained through single-grain measurements could illuminate the past dynamics of rivers.

PALEOGENE SEDIMENTARY RECORDS ONSHORE NEW CALEDONIA (SOUTH-WEST PACIFIC): IMPLICATIONS ON THE TIMING OF THE NEW CALEDONIAN OBDUCTION

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Obductions are unusual tectonic events observed only in a few places over the world. The associated sedimentary records are generally poorly preserved and/or strongly tectonized. However, in New Caledonia, outcropping Upper Cretaceous-Paleogene sedimentary successions and particularly Eocene “flysch-like” turbidites have been interpreted to record a major change in geodynamic regime from Late Cretaceous extension to Eocene compression, which would have led to the obduction of oceanic mantle onto the Norfolk Ridge continental ribbon. This study provides new descriptions of those successions from outcrops and from an extensively cored onshore petroleum well, CADART-1 (1700 m of cored succession from the Upper Cretaceous to the Late Eocene). Detailed sedimentological, stratigraphic and mineralogical descriptions, including facies analysis, biostratigraphic datings, petrographic point count analysis and hyperspectral core logging were performed and allow us to discuss the tectonostratigraphic evolution of New Caledonia during the Paleogene. The Upper Cretaceous comprises a transgressive syn to post-rift siliciclastic succession with deltaic sandstones overlain by deepwater silicified mudstones. During the Paleocene, carbonate deposition prevailed with ca. 150 m-thick pelagic mudstones (*Globigerina* Limestones) and calciturbidites (Adio Limestones). At the Paleocene-Eocene boundary, these carbonates were abruptly overlain by a ca. 800 m-thick interval ranging from the Early to the Middle Eocene made up of siliciclastic, thin to medium-bedded turbidites (Lower Bourail Flysch). The resedimented material is mainly quartz, feldspar, and calcareous extraclasts likely to be derived from the pre-rift basement and cover of the Norfolk Ridge. During the Bartonian, a return to carbonate sedimentation was recorded with a 1 km-thick succession of thin-bedded bioclastic calciturbidites with benthic foraminifera (Middle Bourail Flysch), thought to be reworked from a coeval shallow water carbonate platform. In-situ shallow water carbonates are indeed known to be deposited onto the Norfolk Ridge basement during the Bartonian (Uitoé Limestones). Finally, during the Priabonian, the succession evolved into fine-grained volcaniclastic turbidites with an increasing content of clinopyroxenes, interbedded with coarsening and thickening-upward debris flow breccia (Upper Bourail Flysch) with extraformational angular clasts derived from the Upper Cretaceous and Paleogene sediments. This 4 km-thick succession has been previously interpreted to record deposition within a flexural basin, with volcaniclastic turbidites and extraformational breccia originating from thrusted nappes and calciturbidites evidencing the reworking of shallow carbonate platforms developed in a forebulge domain. However, the lack of material derived from ophiolitic nappes, the relatively distal and fine-grained character of turbidites and overall the deposition of deepwater deposits since the Late Cretaceous lead to explore alternative hypotheses. For example, the alternations between clastic-dominated and carbonate-dominated sedimentation are thought to reflect successive periods of carbonate platform development and drowning, which might be linked to subduction-related vertical movements but also to global paleoceanographic changes (eg. PETM...). We also discuss the origin of the breccia of the Upper Bourail flysch, notably whether such submarine intra-slope instabilities are derived from an active thrust front or from any other tectonic-related slope increase. Evaluating such hypotheses is key to address the origin of the Eocene flyschs of New Caledonia and ultimately should help to better understand the timing and tectonics of ophiolitic nappe emplacement.

DISTAL SUBMARINE CARBONATE FANS DO NOT EXIST?

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Investigations of several hundreds of case studies of Gravity and Slope Carbonates (GSC), from Precambrian to modern, have revealed the global scarcity of distal, detached, submarine calciturbidite fan systems. By "distal submarine" we consider the deeper marine environments that develop away from the continental margins. It is still not clear whether this absence is the consequence of our inability to recognize these particular types of GSC in the geological record, the result of geological sampling bias or a genuine sedimentological global pattern, the controlling factors of which have to be addressed.

Whilst these distal carbonate fans are formed by typical bioclastic turbidites that are preserved in deeper marine settings, it is hard to conceive that they could be confused with other types of carbonates. When they, however, are formed by coarser and poorly sorted material (i.e. debris flows) sourced from carbonate factories and preserved in ambiguous, uncertain (poor data set, subsurface) or complex geological setting, there is room for confusion with proximal, attached GSC or even in situ deposits of carbonate factories. In addition, continental margins and genuine distal geodynamic settings can be difficult to reconstruct in mesozoic and older stratigraphic intervals, as a result of tectonic processes.

The global paleogeographical reconstructions used in recent GSC studies, indicate that all GSC occurrences are related to continental plates. Furthermore, the majority of the well-documented GSC occurrences are attached or adjacent to their carbonate factories, clearly positioned in proximal geodynamic settings. It is therefore considered that our knowledge on GSC deposits is limited to carbonate systems in proximal settings. For Mesozoic and older times, this can be the result of the geodynamic filters. For the Tertiary and modern times, this bias could be caused by the limited access to distal and deeper marine settings.

However, based on our incomplete and biased knowledge on GSC, one cannot conclude from our study that distal submarine carbonate fans do not exist. Hence it is critical to discuss prevailing conditions and processes that could control their possible occurrence and characteristics in the fossil record, and in modern environments.

Deep-water siliciclastic and distal turbidite fans are generally related, directly or indirectly, to river and delta systems that developed on continental shelves. During sea-level lowstands, the deep incision of the marine continental shelves can form submarine canyons. River-delta filtering and increasing sedimentation during lowstands, do not operate in carbonate systems. Sediment production in carbonate factories can be associated with organic frame building (tropical and microbial factories), but also early lithification processes. Both will prevent the availability on the continental shelf of loose muddy-to sandy sediments that can be incorporated in gravity-flows. Despite these limitations in the generation of distal carbonate fans in comparison to siliciclastic fans, a series of parameters can be evaluated that might play a role like the nature of the primary sedimentary source, the sedimentary profile, the presence of submarine canyons, nature of a secondary sedimentary source, stratigraphic architecture of carbonate producing systems and of proximal GSC, as well as the age and paleogeography.

QUESTIONING SEQUENCE STRATIGRAPHY CONCEPTS AND PRACTICES IN CARBONATE SEDIMENTARY SYSTEMS: INSIGHTS FROM STRATIGRAPHIC FORWARD MODELS

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In this presentation we criticize the general carbonate sequence stratigraphic concepts and its application to stratigraphic correlations and propose a quantitative carbonate sequence stratigraphic approach based on stratigraphic forward modeling.

Sequence stratigraphic methods have been applied to shallow-water Carbonate Sedimentary Systems (CSS) in academia and petroleum industry since the 80's. They have been used to establish stratigraphic correlations between distant locations, to analyze sea level changes and other global-local geological parameters during the Phanerozoic and to support hydrocarbon carbonate reservoir modeling. Sequence stratigraphy provides a theoretical frame to analyze carbonate stratigraphic records and to inverse, from stacks of carbonate rocks, basin-to-global parameters such as accommodation, sea level, subsidence or various depositional processes. Its popularity is rooted in its perceived simplicity-correlating regressive-transgressive cycles interpreted from single core, log or outcrop datacombined to an apparent linear mathematical construction, which can explain complex carbonate stratigraphic architectures with only two parameters: accommodation and sedimentary flux, often simplified to accommodation only. This simple sequence stratigraphic principle, generally illustrated in 1D or 2D for describing physical processes that operate in 3D, are expressed by triangles representing the ratio between accommodation and sedimentation rates (*A'/S'*). In practice, complex 3D carbonate stratigraphic architectures are described by vertical sequence stratigraphic trends (3rd-4th order stratigraphic sequences), interpreted in 1D, represented by triangles and correlated as stratigraphic sequences. It implies that preserved carbonate stratigraphic architectures are correlated to a unique *A'/S'* time curve. This convenient approximation is founded, rarely discussed, on two implicit hypotheses: carbonate production is constant in time and space, and *A'/S'* parameters preserved in the stratigraphic records match theoretical *A'/S'* parameters, that control the CSS.

Outcrop surveys and stratigraphic forward models of carbonate platforms show that, despite unique accommodation curve and time constant carbonate production, the preservation of theoritical *A'/S'* (Accommodation rate / Sedimentation rate), one of the fundamental parameters of sequence stratigraphy, is not complete and not unique across simple carbonate platform stratigraphic architectures. Apparent *A'/S'* sequence stratigraphic parameters preserved in the stratigraphic records are variable in time and space and are distinguished from the theoretical *A'/S'* parameters which control the stratigraphic response of the CSS. During overall accommodation increase, regressive trends can be time equivalent of transgressive trends and strata can be formed by coeval shallowing and deepening upwards sequences. Apparent *A'/S'* trends are not systematically correlated between proximal and distal locations and do not mark specific stratigraphic architectures. This is the direct consequence of the spatial and synchronous variations of carbonate production rates along the platform profile.

These results indicate that the construction of carbonate stratigraphic architectures, including carbonate reservoir models, cannot be simply based on standard sequence stratigraphic correlations of distant locations. Inversion of accommodation curves from real stratigraphic record is possible, but dependent on time-depth functions and on the local preservation of thickness and bathymetry parameters for each time layer. Given hypothesis of carbonate production, sedimentary profile and initial topography, these accommodation curves can be inversed from real CSS and tested with stratigraphic forward modeling tools.

POROSITY AND PERMEABILITY-REDUCTION BY CLAY MINERAL AUTHIGENESIS IN AN UNDERGROUND GAS STORAGE FIELD, NORTH ALPINE FORELAND BASIN, AUSTRIA

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Secondary processes within reservoir sandstones during and after hydrocarbon production are poorly understood. This study looks at the effect of secondary water fill on a sandstone reservoir within a time span of eight years. The reservoir rocks consist of medium grained litharenites with large clasts of shales and carbonates. They originate from a depleted gas reservoir which has been converted into an underground storage field for natural gas. Gas production resulted in a rise of the gas-water-contact of about 30 m. Based on their initial and final gas and water saturations, four zones can be identified.

Observed diagenetic changes in all four zones include carbonate cementation, K-feldspar overgrowths, authigenic quartz overgrowths, pyrite formation, and poorly crystallized authigenic clay minerals. However, the authigenic clay mineral fraction differs significantly within the zones. Total clay mineral content and crystallinities of smectite, chlorite, kaolinite and illite increase from the gas-bearing to the initial water zone. Additionally, expandable clay minerals and kaolinite were not identified in the gas-bearing zone. This is different in the secondary watered zones, where smectites and kaolinites are developing. The study shows that within a maximum of eight years from the start of water influx into the gas zone new clay minerals are forming.

The porosity and permeability reduction caused by this artificially induced process might continue and could also be of relevance within other producing reservoirs, where water saturation increases during production.

MUDSTONE DEPOSITIONAL PROCESSES AND SEQUENCE STRATIGRAPHY IN THE PERMIAN ICEHOUSE-TO-GREENHOUSE TRANSITION, KAROO BASIN, SOUTH AFRICA

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Although mudstones represent the most volumetrically significant proportion of the marine sedimentary record, their fine-grained characteristics have limited their interpretation as mostly being deposited in low-energy environments, principally by suspension settling. However, a recent reexamination of mud transport mechanisms has recognised the common occurrence of intermittent relatively high-energy processes, and renewed research has begun to identify subtle stacking patterns in mudstone successions.

The Permian Ecca Group of the Tanqua depocentre (SW Karoo Basin, South Africa) represents a complete exhumed basin-floor to shelf succession. Although there is still uncertainty on the palaeoenvironmental setting of some periods/parts of the Karoo Basin during the Permian time, it may represent a lake, an inland sea with partial/permanent connection with the open ocean or some intermediate setting with strong salinity fluctuations. Moreover, the Early Permian was a time of significant changes in the global carbon cycle and oceanic oxygenation linked to the transition from glacial to post-glacial conditions (icehouse to greenhouse-world transition). However, whether glacial conditions were still present and preserved across different parts of southern Gondwana during the Middle to Late Permian is still a matter of debate.

Here, a 950 m-long core from a research borehole in the Tanqua depocentre is described for the first time. It comprises a thick mudstone-dominated succession overlain by sand-rich basin-floor fans, which are well exposed at outcrop. The basal part of the succession is characterized by 5 to 15 m-thick units of 0.5-5 mm inverse to normal graded siltstone beds interpreted as hyperpycnites separated by units of finer grained bioturbated mudstone 5 to 20 m thick. Two 5-10 m-scale deformed units interpreted as slumped or remobilized material are present. These cyclical and relatively well-organized units are overlain by a less organized, finer-grained unit with an increasing amount of thin and graded sandy turbidites beds. The top of the succession is characterized by three sand-rich units interpreted as basin floor to base of slope deposits. A relatively monospecific ichnofacies association including a dominance of Helminthopsis and Phycosyphon with secondary traces including Planolites, Teichichnus and Chondrites indicates a soft-ground marine environment with punctuated stressed conditions that could be the result of freshwater input derived from a river delta. The transition from the basal well-organized hyperpycnites units to the less organized finer grained mudstone may indicate a major basin deepening and/or the end of glacially influenced sedimentation in the SW Karoo Basin.

These preliminary observations indicate the presence of higher energy than previously thought in the muddy part of the SW Karoo Basin. Regional correlations indicate that this succession is time-equivalent to a 450 m-thick basin-floor fan and overlying base of slope channel-levee complex, only 70 km across strike in the Laingsburg depocentre. Ongoing work is focussed on determining the expression of these major changes in sand supply in the mudstone succession across basin margin strike, in order to test the applicability of sequence stratigraphic models in fine-grained sedimentary systems.

A 2000 KM-LONG GREAT BARRIER REEF IN WESTERN AUSTRALIA DURING THE OLIGO-MIOCENE: RESILIENCE OF CORAL REEF SYSTEMS TO LONG-TERM ENVIRONMENTAL CHANGES

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The Cenozoic carbonate sequences of the Western Australian margin constitute excellent archives of Australia's past climate and sea levels. Oligocene to recent carbonates of this region are largely dominated by subtropical to tropical heterozoan carbonate assemblages. However, several publications have recently provided evidence for a Middle Miocene development of coralgal reefs in the northern part of the Western Australian margin.

Here we present an extensive sedimentological and geophysical dataset covering a > 2000 km transect along the Western Australia margin. The integration of high resolution stratigraphic data from offshore well samples with outcrop data and basin-scale 2D and 3D seismic interpretation has revealed the existence of a coralgal barrier reef system that extended over at least 2000 km from south to north. The high quality 3D seismic datasets that cover most of the margin allow reconstructing the stratigraphic architecture and geomorphology of this reef system at very high resolution. Biostratigraphic and Strontium isotope dating on 15 wells together with outcrop evidence allow constraining for the first time the timing of reef development across the entire margin. The analysis shows that reef development initiated at ca. 27 Ma in the northern part of the Western Australian margin, following a global decrease of atmospheric pCO_2 and a period of global eustatic rise at the onset of the Oligocene warming period. This timing coincides with the onset of widespread coral reef development across SE Asia. Regional seismic mapping shows that this barrier reef system persisted throughout the Oligocene and early Miocene, with intermittent phases of demise and karstification during the eustatic lowstands (driven by the fluctuations of the Antarctic ice-sheets). The northward migration of the Australian continent together with the onset of the Middle Miocene Climatic Optimum resulted in the expansion of the tropical climate belt to the southern part of the margin, where barrier reef growth is observed after ca. 16 Ma. The barrier reef system persisted throughout the Middle Miocene, despite repeated platform exposure and karst development coincident with high amplitude eustatic lowstands. Regional backstepping and progressive drowning is observed after 10^{-6} Ma, possibly due to changes in oceanography following plate tectonic reorganisation in SE Asia, as well as increase in clastic input from the tectonicallyreactivated Western Australian hinterland. Plio-Pleistocene coral reef growth along the edge of the continental margin only persisted locally and forms what is known today as the isolated reef platforms of Ashmore/ Sahul reefs, Scott Reef and the Rowley Shoals.

This Oligo-Miocene "Great Barrier Reef" was as extensive as its present-day cousin, but it had an extraordinary longevity (~ 20 Million years), in contrast with the modern Great Barrier Reef that is only <1 Million years old. The discovery of such an extensive barrier reef system that persisted during times of fluctuating but elevated atmospheric CO_2 concentrations (ranging from pre-industrial levels to 500 ppm) provides a unique opportunity to understand how carbonate reefs respond to long-term climate changes, and how coral reef systems may develop in a predicted warmer future.

COMBINING FULL-VOLUME 3-D SEISMIC INTERPRETATION WITH QUANTITATIVE SEISMIC GEOMORPHOLOGY AND MODERN PROCESS-BASED ANALOGUE DATABASES: THE NEXT GENERATION TOOLS FOR STRATIGRAPHIC ANALYSIS AND RESERVOIR CHARACTERIZATION

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Following three decades of technological innovation, both industry and academic geologists have access to 3D seismic datasets imaging extensive areas at very-high resolution. How seismic stratigraphers will efficiently use this considerable amount of data to improve their understanding of the subsurface in a cost-effective timeframe will mainly rely on (1) using global (“full-volume”) horizon extraction and attribute mapping tools; (2) an understanding of their limitations and an awareness of the stratigraphic significance of the attribute maps interpreted; (3) a solid knowledge of sedimentology and geomorphology of ancient and modern systems and; (4) the integration of queryable, analogue geospatial databases.

Once stratigraphically-significant attribute maps have been generated the best approach for depositional interpretation is to use modern analogues with similar geomorphology. Quantitative seismic geomorphology has been mainly applied to fluvial channels to predict their reservoir properties. However comparing the geometries of individual subsurface elements to their modern counterparts can also help predicting the characteristics of their parent depositional system (process regime, neighbouring depositional elements and range of lithologies). Here we apply quantitative seismic geomorphology to a broader range of fluvial to shallow marine depositional elements using a number of subsurface case studies.

This approach is illustrated through the use of channels and channel belts. Measurements of channel parameters (distance between inflection point, along channel length, curvature amplitude, channel width) are used to find similar modern channel stretches based on query of an extensive modern channel database. It enables the determination of likely reservoir facies as well as the prediction of ranges of applicable depositional environments. In areas of higher quality seismic, shallow marine depositional elements (beach ridges, mouth bars, barrier islands...) can sometimes also be mapped. Combining surface mapping and processbased, hierarchical classification allows further constraining the overall process regime of the parent “shoreline”. Query of a modern geospatial database then permits identification of a suite of suitable analogues and interrogation of reservoir characterization data below seismic resolution. This database-assisted, quantitative seismic geomorphologic approach allows placing a particular set of seismic observations in an uncertainty depositional framework.

LOOKING FOR ENVIRONMENTALAND BIOSIGNATURES IN HYPERSALINE MICROBIALITES: A COMPARISON OF ANCIENT AND MODERN SEDIMENTARY SYSTEMS

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In microbialites, the precipitation/dissolution, and the composition and morphology of minerals depend on three factors: (1) environmental (or extrinsic) physical and chemical conditions, e.g., water composition (e.g., pH, alkalinity, T°), temperature, light, hydrodynamics; (2) microbial activity, dominated by several interdependent autotrophic and heterotrophic microbial guilds modifying their surrounding environment; (3) physical and chemical properties of extracellular polymeric substances (EPS) and cell material, often constituting the substrate for mineral nucleation. This study presents and compares two contrasted modern microbialite systems: one in a restricted marine lagoon (Cayo Coco, Cuba), the other in a hypersaline continental lake (Great Salt Lake, USA). In each example, we characterized water chemistry, microbial activity, EPS properties, mineral products (morphology, mineralogy, chemistry) and their succession, i.e., parageneses, in order to determine the relative influence of microbial and environmental factors on their formation. The evolution of the primary mineral products during early diagenesis, i.e. the first kyears, was also assessed. Finally, we compared the two modern case studies with various examples from the fossil record (Miocene, Cretaceous, etc.) to evaluate the preservation, but also the possibility to differentiate primary microbial and environmental signatures in ancient microbialites.

ICHNOFAUNA RESEARCH AS A TOOL FOR UNRAVELING THE PALEOCLIMATOLOGY AND PALEOECOLOGY IN ACTIVE CONTINENTAL MARGINS: A CASE STUDY FROM THE CENOZOIC SUBMARINE FANS OF PINDOS FORELAND BASIN IN ACHAIA, WESTERN GREECE

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Trace fossils and ichnofabrics were studied in their sedimentological context within the stratigraphic sections and from fallen slabs collected from talus material. To capture a representative selection of available ichnotaxa, a preliminary determination of ichnotaxa in the field helped to document each kind of trace fossil by means of high-resolution digital photographs. The purpose of this paper is to improve the knowledge of how the sub-basin of Tritea, part of Pindos foreland basin in western Peloponnesus, developed during the Late Eocene to Early Oligocene. The Ichnofacies that have been documented are: A. The Eocene deposits contain the ichnotaxa *Ophiomorpha rudis, Planolites beverleyensis, Cosmorhaphe, Nereites, Chondrites, Scoyenia, Monocraterion, Teichichnus, Skolithos, Zoophycos* and *Phycosiphon*, and B. The Oligocene deposits contain the ichnotaxa *Ophiomorpha rudis, Planolites beverleyensis, Aulichnites, Arenolites (Arenicolites), Paleodictyon strozzi, Cosmorhaphe, Chondrites, Scoyenia, Skolithos, Monocraterion* and *Psilonichnus*.

The detailed ichnofaunal research indicates: 1. The difference between proximal and distal environment is shown by the high abundance and low diversity proximal environment and the low abundance and high diversity of the distal one. 2. Comparing the equivalent sedimentary locations e.g. a channel with a lobe in proximal and distal respectively sub-environments, the same differences as above were recognized. The tracefossils assemblages in a channel environment are higher and the diversity is lower in relation the lobe environment. The same was also recognized when interchannel with interlobe deposits, and levee deposits in an inner environment and in an outer environment were correlated, respectively. 3. The level of oxygenation in an inner fan environment, such as in a channel, interchannel or levee environment, was recognized to be low due to the high deposition rate and high energy flows, and the turbidity currents which transported material from the continental shelf and shallow upper slope towards the deeper parts of the basin. Generally, tracefossils have the difficulty to survive except of some specific species. The level of oxygenation in an outer environment such as in a lobe, interlobe, or levee was recognized to be high, in relation to the inner fan environment, due to the dilute flows, lower deposition flows and lower energy conditions. 4. Comparing Eocene and Oligocene deposits in the same sub-environments (lobe sub-environment), the studied ichnofossils provided evidence that there was a difference between diversity, the length and the thickness of the respective ichnofossils. The section with the Eocene deposits has tracefossils bigger in length, thickness and with better geometry than those of the Oligocene deposits.

The sections which are closer to the Pindos thrust are characterized by high abundance, low diversity and low oxygenation levels, in contrast to the distal areas from Pindos thrust which are characterized by low abundance, high diversity and high oxygenation level. The ichnodiversity and ichnoabundance decrease gradually upward, reflecting the impact of the changing depositional environments from basin floor fans, to slope systems and then to shelf environments. The regional basin-fill history, rather than the global climatic changes, was probably the fundamental controlling factor on the distribution of trace fossils across the E/O boundary.

SEDIMENTOLOGY AND SEQUENCE STRATIGRAPHY ANALYSIS OF FLUVIAL AND AEOLIAN SYSTEMS WITHIN TERRESTRIAL AND NEARSHORE ENVIRONMENTS: NOVEL INSIGHT AND CLIMATE IMPLICATION

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Stratigraphic correlations are often considered as impossible in thick accumulations of fluvial deposits where arid conditions are often underestimated. In fact, most of the time, aeolian deposits in arid environments dominated by ephemeral alluvial fan or braided river are poorly preserved and particular attention should be paid to any sedimentological marker of aridity, such as wind-worn stones (ventifacts), sand-drift surfaces and aeolian sheets. Only detailed study of alluvial plain facies and ephemeral streams provide indications of climatic conditions within the sedimentary basin, whereas fluvial system only reflects climatic conditions of the upstream erosional catchment. Moreover, in such context the deposition of conglomerate of alluvial fan system could correspond to a peak of aridity without an increase in tectonic activity.

Conversely, the sedimentary record of aeolian deposits, often considered as preserved in arid desert basin, can occur under semi-arid and even humid climates, and from near the Equator to the Arctic Circle. Ventifacts are climate-sensitive sedimentary features that provide evidence for long periods without any vegetation in terrestrial environment under hot or cold climate. Therefore, they can allow recognizing desert conditions, even where no aeolian dune deposits are preserved. Moreover, the well-preserved widespread paleoregs seem to mark major stratigraphic discontinuity above a geomorphic surface remained a long time without vegetation as a result of a very dry climate, hot or cold.

Detailed sedimentological study and the recognition of bounding surfaces of regional extend (sanddrift surface, palaeosols, flooding surface...) allow for the identification of stratigraphic cycles, permit correlation within time and space and precise the climate conditions. Moreover, these detailed sedimentological and stratigraphic analyses highlight the influence of climate or tectonic change on sediment facies and depositional environments.

Applied to various Permian and Triassic continental sections in Europe and USA and Jurassic–Cretaceous sections in China, this methodology allows to define fluvial and aeolian interaction processes through time and space, to discuss the allogenic vs autogenic controls and the preserved sediment record within terrestrial and nearshore environments. The recognition of sand-drift surface and maximum flooding episode at the scale of genetic unit, provide a valuable tool for stratigraphic correlation within continental environments devoid of any biostratigraphic markers. Moreover, such results allow to discuss the climate condition of the basin.

THE BEGINNING OF MESOZOIC SEDIMENTATION OF THE NORTH AND EAST OF FRANCE: PALAEOENVIRONMENTAL RECONSTRUCTIONS AND IMPLICATIONS ON GEODYNAMIC EVOLUTION OF THE TRIASSIC IN NW EUROPE

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The beginnings of Mesozoic sedimentation in north and east of France are located in three presentday areas: the Paris Basin, the Rhine Graben and the Bresse-Jura Basin. If the relations between Paris and German basins are exposed in recent papers, especially for the Early Triassic, the relation with BresseJura Basin is less understood even it is considered as a sub-basin connected with German and Paris Basin.

The aim of this paper is, from new data and correlations in the northern part of France, (1) to reconstruct isopach and palaeogeographic maps, and (2) to discuss the geodynamic evolution of the north-west European domain during the Triassic.

The Triassic series mainly crop out in the eastern part of France and only well-log data can provide a continuous record. By studying outcrops, core data and a complete set of wells, we can carry out correlations of the Triassic series between basement and Early Jurassic deposits. Around 600 wells are correlated using the principles of high-resolution sequence stratigraphy to establish the 2-D and 3-D geometries. The use of geomodeller Gocad allow to produce palaeogeographic and isopach maps.

At the scale of the whole study area, an unconformity is observed between Permian and Triassic systems. Mesozoic sedimentation began during the Olenekian; the ephemeral fluvial systems indicate warm and arid climatic conditions. At the top of the Lower Triassic series, another tectonically induced unconformity is observed: the Hardegsen unconformity, which is intra-Spathian in age. That leads to the development of a new sedimentation area to the west. This tectonic activity creates new source areas and a new fluvial style, with marine influences at the distal part of the systems. Both during the end of the Olenekian and the Anisian, the presence of palaeosols, micro-and macrofloras indicates less warm conditions throughout the region. During the Anisian and Ladinian, continental sedimentation is characterized by a retrogradational trend. In other words, the fluvial system evolves towards fluvio-marine environments, attesting to a direct influence of the Tethys Ocean in the eastern domain. The maximum flooding episode is Ladinian and corresponds to well-extend Muschelkalk facies to the west. The progradational trend is characterized by evaporite sedimentation in the eastern domain and alluvial fan deposits in the western part. The sediment supply comes from the Armorican Massif and the climate conditions are warm and humid. The sedimentation is controlled by faults creating subsiding areas where salt series are preserved. During the Middle Carnian, the climate becomes more humid, without evaporite and the fluvial systems come from the north. This episode marks the beginning of a new retrogradational cycle that end in Early Jurassic. After this humid episode, more warm conditions occur with evaporite deposits and alluvial fan sediments preserved only in the western part. An intra-Norian unconformity, i.e. Early Cimmerian unconformity, allows the separation of two basins, i.e. the Paris Basin and Bresse-Jura Basin. Above the unconformity, an acceleration of the retrogradational trend occurs with transition from dolomitic sebkha, to marine Rhaetian sandstone and then to Liassic limestones.

CAN WE PREDICT THE QUANTITY OF CARBONATE FORMED IN A SEDIMENTARY BASIN? FIRST INSIGHTS FROM A "SOURCE-TO-SINK" APPROACH DEVELOPED FROM THE MODERN GREAT SALT LAKE, UTAH, USA

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The "source-to-Sink" approach that was developed during the last decade has offered new perspectives to understand the dynamics of sedimentary basins. This method has led to quantify erosion, transport and sedimentation in order to estimate and predict the volume of sediments deposited in a basin, and its consequences. However, currently this approach is mostly limited to clastic deposits because only solids particles are usually considered. Carbonate deposits predominantly result from the in-situ precipitation of $CaCO_3$ from the Ca^{2+} and HCO_3^- ions in solution.

The Great Salt Lake is a modern endoreic lake emplaced in northwestern Utah, USA, within the Basin and Range geodynamic province. Despite its substantial surface area, averaging 4480 km^2, this lakeremains very shallow with a maximal depth limited to 10 m. This shallow phase only dates back 11,500 years. The endoreic lake character of the Great Salt Lake implies that its water volume and extension reflect the balance between the volume of inputs (rivers: 66%; rainfall: 31% and subsurface: 1%) and the outputs (mainly evaporation). Consequently, the majority of the incoming ions and particles stay in the lake system where they can precipitate and form sedimentary rocks. During the Great Salt Lake phase, an extensive carbonate factory, made of microbialites and ooid sands developed along the margins of the lake, covering more than 1000 km^2. As they result from the in-situ precipitation of $CaCO_3$, the carbonate volume should be a function of the Ca^{2+} and HCO_3^- budget, and thus reflecting their inputs since 11,500 ^{14}C BP years.

In this context, a "source-to-Sink" approach was deployed to quantify and compare the amount of Ca^{2+} released in the system and what is stored within carbonate rocks. The monitoring of the main tributaries of the Great Salt Lake by the USGS (since 1944) enables quantification of the flow as well as the inflowing water composition. An extrapolation of these values allows to estimate a budget of ca. 1.3 gigaton (Gt) of Ca^{2+} that arrived in Great Salt Lake since 11.500 ^{14}C BP years. A calculation of the Ca^{2+} stored within the microbialites and ooid sands was estimated from the extension and thickness of the carbonate deposits and is also close to 1.3 Gt. These balanced values between inputs and storage of Ca^{2+} imply that: (i) all the incoming Ca^{2+} could have been stored as carbonate sedimentary rocks (and this, quickly as confirmed by the low concentration of Ca^{2+} of the mean Great Salt Lake's water in comparison with the inflowing rivers), and (ii) it is possible to predict the volume of carbonate production within the basin with all the resulting implications (especially economical) by estimating the incoming budget of Ca^{2+}.

Even if this study only consists of an initial controlled step of a "source-to-Sink" approach applied for carbonate deposits in a closed system, this paves the way for future development of this approach to open (e.g. marine) and fossil systems.

MICRITIZED MICROPOROUS MIOCENE CARBONATES FROM ONSHORE/OFFSHORE EASTERN SPAIN: IMPLICATIONS FOR TIGHT LIMESTONE RESERVOIRS

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Cenozoic marine limestones containing larger foraminifera, corals and coralline algae are a common hydrocarbon reservoir rock. Such reservoirs frequently show complex micritization processes and porosity systems including diagenetic 'chalky' microporosity. In order to gain understanding on the origin of this microporosity, this study characterizes and constrains the timing of the diagenetic processes that affected the Langhian platform carbonates of El Penedès, in onshore NE Spain, as well as the offshore counterpart strata in the Tarraco Field (Gulf of València). The Langhian age of the deposits is based on the occurrence of Borelis melo in the onshore, and of *Borelis arpati*, *Heterostegina papyracea*, *Amphistegina mammilla* and *Amphistegina bohdanowiczi* in the offshore. In the onshore, these micritized and microporous carbonates belong to the Bellvei Facies, whereas in the offshore constitute the Amposta Limestone, formerly defined as Amposta Chalk, which is a non-economic hydrocarbon reservoir. In the Penedès Basin, the Langhian outcrops are characterized by coral-bearing carbonates and poor development of the red algal facies. On the other hand, the Amposta Limestone facies in the Tarraco Field contain abundant coralline algae and exhibits cyclic decametric to metric alternations of rhodolith-rich and rhodolith-poor facies, and is therefore considered as representative of deeper depositional settings. The Amposta Limestone succession observed in the Tarraco Field developed during a transgression and was finally drowned and capped by a glauconitic unit. In the onshore, the top of the Bellvei Facies is locally karstified and overlain by continental to coastal sandstones of probable Serravallian age. According to the Loreau's classification of micrites, the samples analyzed in both offshore and onshore rocks exhibit punctic, serrate, meshed and coalescent microfabrics. The size of the low magnesium calcite crystals observed is mainly around 1 to 4 µm. Pore-throat sizes are usually below 0.44 µm. The porosity in the Amposta Limestone varies between 10-26% and permeability from 3 to 20 mD, whereas in the outcropping Bellvei Facies porosity values range between 30 and 40%, and permeability between 20.35 and 181 mD. There is a pervasive micro-dolomitization affecting in different degree the Amposta Limestone. The outcrops of the Bellvei Facies are mostly not dolomitized. The $\delta^{18}O$ isotope values of the onshore samples mainly plot to the right of the meteoric calcite line ($\delta^{18}O$=-5‰) but very close to it, whereas the $\delta^{13}C$ values range between -2‰ and -7‰. In the offshore samples, $\delta^{18}O$ values are significantly lighter indicating a higher temperature gradient related to burial and dolomitization. Leaching of trace elements is related to the degree of micritization. The carbonates most depleted in trace elements are the ones showing a higher degree of micritization. Preliminary results suggest that meteoric groundwater over long residence times played a fundamental role in the diagenetic alteration, leaching and micritization of the rocks studied. The Miocene Bellvei Facies and the coeval offshore Amposta Limestone are useful analogues to other comparable reservoir facies in the Caribbean, Middle East and SE Asia.

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THE SABIÑÁNIGO SANDSTONE DELTAS OF THE NORTHERN JACA BASIN (SOUTH-CENTRAL PYRENEES, SPAIN)

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In the Jaca Basin (south-central Pyrenees, Spain), the Lutetian-Bartonian boundary is recorded in the basal unconformity of the last sandy turbidite system of the Hecho Group (Rapitán system). This is progressively replaced vertically by prodelta mudstones (Larrés Marls), which are genetically related to the overlying deltaic complex (Sabiñánigo Sandstone). The Sabiñánigo Sandstone is in turn vertically replaced by another mudstone-dominated succession (Pamplona Marls), which is part of an upper deltaic complex (Atarés system). This dominantly deltaic succession represents the transition from the end of the underfilled stage to the overfilled conditions of the Jaca thrust-top basin, controlled by the last phases of activity of a major Pyrenean tectonic structure (Eaux-Chaudes thrust).

In this work, a reinterpretation of these deltaic systems, and their palaeogeographic implications is attempted, with different scales of cyclicity documented through both limbs of the Basa anticline. The study is based on geological mapping, facies analysis and stratigraphic correlations of the eastern and central parts of the Jaca Basin. The data has been collected from several outcrops along the northern Santa Orosia syncline, and continuing along the southern limb of the succeeding Basa anticline (eastern expression of the Biniés-Jaca thrust), until the Berdún region (western Jaca Basin).

The integration of detailed facies and stratigraphic analysis with petrographic characterization suggests two coeval sedimentary sources/systems interacted during deposition of the Sabiñánigo deltaic complex. One of them is mainly recorded in the northern limb of the Basa anticline and in the eastern areas of the southern limb. Here sediments are primarily represented by flood-dominated delta front sandstone lobes, occasionally tidally reworked during transgressions. Their equivalent coastal deposits, such as mouth bars and distributary channels can also be observed. Their petrography is characterized by the presence of hybrid sandstone fragments interpreted as the early erosion of the turbiditic basin, indicating the dominant contribution of a north-eastern source area. In the southern limb of the Basa anticline, these north-derived deltafront sandstones thin and fine westwards, passing progressively into hyperpycnite beds (hyperpycnites), and finally into the underlying prodelta mudstones. Here, north-derived depositional units form distinctive clastic wedges interfingered with massive and highly bioturbated sandstones and siltstones, which are the dominant facies in the south and east, and can only be observed in the north when associated with transgressive periods. These bioturbated sandstones can preserve signatures of combined-flow structures and they are mainly interpreted as outer-shelf deposits. They are characterized by abundant carbonatic extrabasinal and monocrystalline dolomite grains, attributed to the erosion of Mesozoic cover rocks of the South-Central Pyrenean Unit, located to the south-east.

The regional correlation of depositional units of he Sabiñánigo deltas allows distinguishing between different sequence hierarchies: large sequences appear to be mainly controlled by the local and regional syn-sedimentary tectonic activity, while higher-frequency sequences were potentially influenced by both orbital and eustatic fluctuations. These last units also show a marked autocyclic compensational stacking, and provide an example to test the applicability of high frequency sequences versus parasequences in deltaic correlations in tectonically-active settings.

MEDITERRANEAN SEASCAPE SHAPED BY CORALLIGENOUS BUILD-UPS

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In the framework of Mediterranean marine benthic zonation, coralligenous (C) is a circalittoral biocenotic complex forming a new solid substrate, mainly produced by the overgrowth and accumulation of calcareous encrusting algae in dim light conditions, and consisting of tridimensional biogenic build-ups. As other benthic bio-constructions, it contributes to seascape formation through geological times, causing geomorphological changes of the seafloor. In the Mediterranean Sea it forms large structures that may be up to 4 m high and greater than 50 m in lateral continuity. Marine bionomists consider the substrate of C to be a key factor in distinguishing the C d'horizon inférieur de la roche littorale, always on a pre-existing hard substrate, from the C de plateau. Originally, the latter was indicated as a biogenic framework developed from the coalescence of rhodoliths; then it was generally indicated as forming a new solid substrate on an originally mobile substrate. However, given the difficulty to investigate the type of substrate of C, some authors suggested that some C de plateau frameworks could have grown on submarine rocky outcrops. C produces various morphotypes on the seafloor, not exhaustively categorized yet. Several terms are used to define C morphotypes, but their application through different geological and environmental settings still remains inconsistent. Only two general categories are reported: 1) banks – flat over more or less horizontal substrata, and 2) rims – structures on submarine vertical cliffs or surrounding the opening of submarine caves. Apulian C is known in literature since decades. Large areas of the Apulian continental shelf have been investigated by acoustic methods from the coastline down to 100 m water depth, in the framework of the BIOMAP project and of a commercial survey. Collected remote data (Multibeam echosounder, Side Scan Sonar and Chirp/Sub Bottom Profiler) have been ground-truthed by ROV and camera inspections. Seafloor mapping techniques allow obtaining large-scale, high-resolution seafloor images for the description of the seascape, and the distribution and extent of benthic habitats. We identified a combination of distinct C morphological expressions, at the scale of meso-and macro-habitat, based on distinctive and ground-truthed C morpho-acoustic facies in which the biogenic frameworks (i.e. coralligenous) prevail as sole biocommunity on the seafloor or associated with other type of habitats. We detected coralligenous morpho-acoustic facies as 0.2 up to 4 m topographic reliefs with steep flanks and a rigid inhomogeneous biogenic framework, characterized by medium to strong Side Scan Sonar backscatter and a variable plan-view geometry. Finally, we propose a new descriptive, objective categorization based on the extrapolation of geometric parameters, such height and Shape Index, to define C morphotypes on sub-horizontal, not only mobile, seafloor. These morphotypes are: 1) tabular banks, 2) discrete reliefs, or 3) hybrid banks.

THE ROLE OF THE SUBSTRATE IN CORALLIGENOUS DEVELOPMENT: EXAMPLES FROM THE PRESENT AND THE PAST

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Coralligenous is the most monumental bioconstruction made by calcareous red algae between 10 and 140 m of water depth in the Mediterranean Sea. Marine bionomists consider the nature of C substrate to be a key factor in distinguishing the C *d'horizon inférieur de la roche littorale* (substrate = rocky cliff), always on an antecedent hard substrate, from the C *de plateau*. Originally, the latter was indicated as a biogenic framework developed from the coalescence of rhodoliths. Then it was more generally conceived as forming a solid substrate settled on an originally mobile substrate. Therefore, the nature of the substrate is fundamental for such genetic definition of the C *de plateau*. However, since controlling the nature of the substrate of C is very challenging, some authors suggested that in some cases the C *de plateau* frameworks could have grown on sub-horizontal rocky outcrops. Moreover, the substrate geometry controls the presentday categorized geomorphological expression assumed by such bioconstruction: 1) banks – flat frameworks with thickness ranging from 0.5 to 4 m mainly built over more or less horizontal substrata, and 2) rims – structures on submarine vertical cliffs or surrounding the opening of submarine caves, generally located in shallower waters than banks. Within this approach, the key factor to distinguish the two morphotypes is basically the geometry of the substrate, sub-horizontal versus sub-vertical. Nevertheless, under the term "coralligenous bank" several C morphotypes were merged: tabular banks, discrete reliefs and hybrid banks. We collected and compared several examples of coralligenous outcrops from present day Mediterranean Sea (Apulian Platform, Egadi islands, Pontine islands) and from the stratigraphic record (Calabria marine terraces, Pleistocene) in order to investigate the nature of the substrate of C and the resulting C morphotypes. On present-day examples, we conducted a systematic analysis on the acoustic data (digital terrain model, seismic profiles) coupled with ROV video analysis to describe substrate and correlated C morphotypes. We investigated the same aspects in several fossil examples, where the present-day outcrop exposition allowed the direct visualization of the substrate and how C developed on it. We collected variable combinations C morphotypes/substrate. In some cases, we recorded the C *de plateau* in its original, genetic definition. In most cases, we identified a suite of other variable substrates, beyond rhodoliths, on which C grew with distinct morphotypes. We conclude that C morphotypes on sub-horizontal substrate do not show a univocal correlation with the type and composition of their substrate. We address the need of a discussion about the meaning of "suitable substrate" for coralligenous development and about the correct use of C *de plateau* definition.

PATCHY DISTRIBUTION OF FACTORY FACIES IN LATE MIOCENE NEARSHORE MIXED CARBONATE-TERRIGENOUS DEPOSITS IN SIERRA DE GÁDOR, ALMERÍA, SE SPAIN

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Mixed carbonate-terrigenous deposits onlap the Betic Triassic dolostone basement in the Chanata area in Sierra de Gádor, Almería, SE Spain. The $^{87}Sr/^{86}Sr$ compositions of oyster samples indicate a late Miocene (Tortonian) age for these rocks. Five main lithofacies were distinguished by logging 13 sections in the three main outcrops in the area: 1) heterometric breccia with bioclastic matrix; 2) coralline-algal packstone with varying amounts of terrigenous content and large oyster shells; 3) branching coralline-algal rudstone; 4) hooked and laminar coralline-algal packstone to floatstone; and 5) *Heterostegina* rudstone. Sandstone, conglomerate, and gastropod wackstone locally occur as additional minor sediments. Facies mapping on photomosaics of the excellent outcrop exposures shows the stepwise nature of the onlap, and the spatiotemporal distribution of facies. Each onlap phase comprises a package of laterally changing lithofacies several metres thick and several hundred metres across, displaying a homoclinal ramp geometry. Breccias directly overlie the basement, making up the shore-line sediments except in a few local occurrences of sandstones with low-angle parallel bedding and lamination characteristic of foreshore deposits. Packstones of varying width extend basinwards of breccias. Trough cross-bedding and vertical (*Skolithos*-like) bioturbation are locally visible; the terrigenous content can be higher than bioclastic carbonate at some points. Rudstones to floatstones of diverse components occur seawards from packstones. No definite pattern of lateral distribution of major components can be observed all over the area. Branching coralline algal rudstones occur both shorewards and basinwards of hooked and laminar coralline packstone to floatstone, which probably formed in seagrass meadows. *Heterostegina* rudstone appears in lenses changing laterally to any other facies. It seems that whereas the hydrodinamically controlled lithofacies, namely breccias and pack-stones, occur in belts roughly parallel to the shoreline, the different types of factory facies, comprising relatively well-preserved, parautochthonous bioclasts have a patchy distribution. Modeled temperatures and salinities based on carbon and oxygen stable isotopes gave normal marine salinities for most oyster samples except for a few that indicate fresh-water input in certain intervals of individual oyster growth. Estimated palaeotemperatures range from 14 to 24°C.

ON THE ORIGIN OF THE PALEOGENE UNCONFORMITY IN THE LATIUM-ABRUZZI CARBONATE SUCCESSION: A SHAVED PLATFORM

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The Latium-Abruzzi carbonate platform constitutes the sedimentary record from Triassic to the late Miocene of southern Tethyan margin outcropping in the Apennines. This sedimentary succession is punctuated by an important hiatus between the end of Cretaceous and the early Miocene. This Paleogene hiatus has been interpreted for long time as the result of prolonged subaerial exposure. However, no evidence of such exposure has ever been documented on the Latium-Abruzzi Platform. This is contrary to the coeval and adjacent Apulia and Lessini carbonate platforms where a broadly developed paleokarst system formed between the Eocene and the early Miocene. The assumption that the Miocene marine transgression deeply eroded a karsified Cretaceous substrate on the Latium-Abruzzi Platform is not supported by the observation that this surface appears in the field as a perfectly flat, bioeroded paraconformable surface. In this work, a marine origin is proposed for this unconformity. From late Paleocene to early Miocene, the Latium-Abruzzi carbonate platform was a shaved isolated platform in the middle of the proto-Mediterranean area, exposed to wave action. Bioclastic sediment accumulated during transgressive and sea-level highstand phases, whereas in the following falling and lowstandstages, sediment was eroded as the seafloor came into the zone of wave abrasion. The sediment eroded from the platform was shed into the basin where it produced coarse bioclastic intercalations in the hemipelagites of the Scaglia Formation. At the end of the Oligocene, when the adjacent basin was filled, a small ramp established in the transitional zone between the platform and the basin. Here cross-bedded carbonates accumulated in middle to outer ramp environments. The inner ramp remained within the zone of wave abrasion such that sediment generated here was washed out into middle and outer ramp environments. Finally, in the early Burdigalian, the Mediterranean progressively evolved into an enclosed sea during the initial stages of the closure of Indo-Pacific connection. The reduction of the wave base depth typical of an enclose sea created an increase of accommodation space allowing produced sediments to accumulate and form complete inner to outer ramp facies belts of the Miocene Latium-Abruzzi ramp.

THE FABRIC OF CONTINENTAL CARBONATES: WHAT HAVE THE MICROBES EVER DONE FOR US???

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What would continental carbonate rocks look like in a world without microorganisms? Which macro-to nano-scale features would change, and which would be the same? Theoretical abiotic physicochemical processes may be invoked to explain many terrestrial carbonate rock-forming processes, but microbes influence crystal nucleation and growth even where they are not needed. This can be demonstrated through petrographic examination of natural samples and synthetic products of controlled environment laboratory experiments.

Laboratory experiments simulating a hot-spring pool and channel show that aragonite rafts form abiotically at the air-water interface. Electron microscopy shows these abiotic paper-thin rafts comprise a meshwork of euhedral needle crystals that become tangled and interlocked. They quickly sink to the bottom of the pool when water surface tension is broken. Euhedral calcite was observed to grow on sunken raft surfaces in cooling waters. Such rafts should be found in natural hot-springs, and indeed they are. However natural Italian hot-spring vent pools are not abiotic, but invariably inhabited by millimetre to centimetre thick mats of thermophilic bacteria and archaea that trap gas bubbles. Accumulation of bubbles eventually causes the biofilm to rise up and float on the pool surface, interacting with the abiotic paper-thin rafts, and so modifying the rock fabric.

Rock lamination is not a characteristic unique to biogenic specimens. Stromatolite-like lamination can also form abiotically, as seen in speleothem-like stalactitic British stream carbonates. In some *Phormidium* stream carbonates of Belgium the presence of seasonally-changing cyanobacterial biofilm seems to result in lamination. Conversely, lack of lamination can be a sign of interference by microbes, as in some Australian (Lake Clifton) thrombolites.

High resolution petrography of 3 m high Pleistocene “chimneys” formed above spring vents in Mono Lake, California, reveal they are constructed of tubes of calcite-entombed cyanobacterial filaments. Electron microscopy and NanoSIMS analyses suggest these tubes are the direct result of calcite encrustation of tubular cyanobacterial mats. If no microbes had been present around the rising vent waters then we postulate that the nano-to macro-scale morphology of the resulting precipitates would have been very different.

In conclusion, microbes are not always needed for continental carbonate rocks to form. However, they have been observed to influence nano-to macro-scale carbonate rock fabrics, and so to create recognisable macro-scale biosignatures, in systems where inorganic solution chemistry already favours carbonate mineral precipitation.

BASIN-SCALE MINERAL AND FLUID PROCESSES AT A MISSISSIPPIAN PLATFORM MARGIN

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Fault-controlled dolomite has been well studied and described in various localities in the Pennine Basin and North Wales. Fluid flow modelling indicates sufficient fluid volumes for dolomitisation could have been supplied along faults from the juxtaposed basinal sediments. Reactive transport models indicate geothermal convection of seawater on the platform margin could have initiated dolomitisation, focusing the position of the dolomite bodies. However geochemical data is consistent with dolomitisation from evolved basinal brines that interacted with siliciclastic sediments and/or volcanics, possibly a result of overprinting by compactionally driven fluids prior to mineralisation.

The Derbyshire Platform is a Mississippian rimmed shelf, the westernmost expression of the East Midlands Platform. On the SE platform margin, 50 km^2 of Visean limestones have been dolomitized, forming two major bodies with an association with major NW – SE trending basement lineaments and volcanics. The onset of compressional tectonics associated with the Variscan Orogeny resulted in multiple phases of NWSE and NE-SW trending fault/fracture controlled calcite cementation and Pb-Zn-F-Ba mineralization. The body is one of several discrete, fault-fracture controlled dolomite bodies that occur on Mississippian platform margins across the Pennine Basin and North Wales. Dolomitisation is known to predate mineralisation but uncertainty lies in why the dolomitisation is localised.

This study uses outcrop and newly available borehole core from the southern margin of the Mississippian Derbyshire-East Midlands Platform to better constrain the timing and mechanism for dolomitisation. Dolomitisation is usually fabric destructive with a range of textures that suggest multiple phases of fluid flux. Geochemical data indicates slightly modified seawater, with a contribution from hydrothermal fluids, was responsible for dolomitisation. These data will be expanded to refine the interpretation and test the hypothesis dolomitisation by geothermal convection of seawater during early burial by seawater was an important pre-requisite for later dolomitisation by hotter, more evolved basinal brines expelled by compactional flow from ruptured, overpressured sediments in the adjacent Widermerpool Basin. Demonstration of a feedback mechanism between these processes has the potential to inform arguments that favour mass fluid transfer during burial diagenesis.

EVIDENCE OF AN EARLY CRETACEOUS HYDROTHERMAL EVENT IN THE MIDDLE JURASSIC LIMESTONES OF THE PARIS BASIN

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In sedimentary basins, the precise temperature in shallow buried rocks (< 60°C) are poorly recorded by classic geothermometers or low temperature thermochronometers. In the last ten years, thermal history and fluid flow periods in the shallow buried Paris Basin have been considerably improved. Different diagenetic studies, coupling petrographic observations and isotopic analyses ($\delta^{18}O_{carb}$) allowed to characterize a main episode of carbonate cementation during the Early Cretaceous, leading to the filling of intergranular space within the Middle Jurassic limestones. On the other hand, the scenarios of fluid flows within a reliable geological history are difficult to reconstruct because of the difficulty in finding calcites with two-phase aqueous fluid inclusions or apatite to obtain (U-Th)/He or fission track ages. These scenarios depend to a large extent on the $\delta^{18}O_{carb}$ interpretations, which are themselves dependent on the assumptions made about the temperature or about of the oxygen isotopes. Consequently, geological interpretations on the same calcite cements, filling-intergranular pore space or fissural porosity, can be diametrically opposed depending on the assumptions made on temperature. This demonstrates that temperature constitutes an important lock in diagenetic studies. The aim of this work is to couple (i) temperature and (ii) $\delta^{18}O$ fluid reconstruction from calcite crystals of the Paris Basin in order to remove the uncertainties on the diagenetic scenarios of this basin. In order to answer this question, a diagenetic study was carried out using (i) classical methods (paragenetic association, stable isotopes) and (ii) a thermometric method developed recently, the clumped isotope or D47 thermometry. The D47 temperatures of the 2 main blocky calcites indicate temperatures of 60°C and 85°C on average respectively for both generations. The thermal history of the eastern Paris Basin, compiled from organic matter, clay minerals and apatite fission track data indicates that the D47 temperatures in calcite are about 20°C to 45°C higher than the temperature recorded in sediments during the Early Cretaceous. We suggest that D47 temperatures recorded in these carbonate cements reflect a short hydrothermal event, probably too short to be recorded by organic matter or clay minerals. The $\delta^{18}O$ fluids calculated by taking into account these D47 temperatures vary from + 2.5 ‰ to + 8 ‰ SMOW. This implies deep ascendant hydrothermal brine circulations. The high $\delta^{18}O$ fluids at the origin of calcite (up to + 8 ‰ SMOW) can be typical of (1) fluids interacting at high temperature with minerals of a crystalline basement or (2) a mixture between hydrothermal fluids and fluids having dissolved a large amount of carbonates.

LARGE-SCALE CYCLIC-STEPS IN CAP-FERRET TURBIDITE SYSTEM (BAY OF BISCAY): EVIDENCES FROM AN EUSTATIC CONTROL IN THE CAP-FERRET AND CAPBRETON CANYONS' ACTIVITY?

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Channels-levees environments are controlled by a complex interplay between erosion and deposition processes due to several features including density flows resulting in complex sedimentary facies and structures such as cyclic steps, scours, antidunes etc. Herein we present uncommonly large examples of this latter sedimentary structures from the Cap-Ferret turbidite System (Bay of Biscay, France). The channellevees complex of the Cap-Ferret system results from the conjunction of the flows from the Cap-Ferret and Capbreton canyons. These latters are both defined in turn as the dominant sediment supplier depending on the sea-level fluctuations and merge in a unique channel-levees complex. The multibeam bathymetric data revealed a train of sedimentary bedforms at the channel-lobe transition zone. These bedforms are uncommon by their size and distribution. They are developed at 4400 m of depth and present a complex interplay between scours and sediment waves. Sediment waves have an average wavelength of 4 km and an average amplitude of 30 m. Large-scale scours (500 to 2500 m wide, 800 m to 6 km long, 15-45 m deep) cover a wide area (about 3 km^2) located between the feeder channel and the crest of the levee, in a less confined environment. Subbottom profiler data offer high resolution modelization of the internal architecture of these scours and sediment waves, exhibiting subhorizontal aggradational geometries on the stoss-side of the sediment waves. The scour and sediment wave succession is interpreted as resulting from cyclic-steps and illustrates avulsion processes. These avulsion processes may be linked to changing in the sediment supply from the Cap-Ferret canyon to the Capbreton canyon.

WHAT DID THE NUMERICAL STRATIGRAPHIC FORWARD MODELS EVER DO FOR US?

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Numerical stratigraphic forward models were first developed in the late 1960s (e.g. Harbaugh & Bonham-Carter, 1970) and Cross (1989) defined such models as "the simulation of product from the known response of a process to a given set of initial conditions". Since then there have been many such models developed, and many applications of them. However, use of numerical stratigraphic forward models is still not as widespread as might have been predicted by Harbaugh and Cross. For example, few studies that interpret depositional process and environment from outcrop or subsurface data support the proposed interpretation by constructing a stratigraphic forward model, even though to do so can offer useful insights of various types. Similarly, in subsurface evaluation for hydrocarbon production or evaluation, application of stratigraphic forward models is probably still less common than, for example, construction of static and dynamic reservoir models. This lack of use is surprising, given the potential benefits these kinds of numerical models offer.

So what can numerical stratigraphic forward models do for sedimentary geologists? Potential beneficial applications fall into two main categories; hypothesis testing via numerical experiments, and probabilistic prediction. Hypothesis testing comprises construction of a numerical stratigraphic forward model to determine whether a proposed interpretation or explanation of strata is physically reasonable. Two examples of this will be presented, one showing how hypotheses for the accumulation of lacustrine carbonates in a synrift setting can be tested, and the second showing how feedbacks between shoreface erosion and flexural isostatic uplift can generate shallow-marine siliciclastic autocycles. Probabilistic prediction utilises the ability of numerical stratigraphic forward models to test multiple scenarios that bracket a range of uncertainty on some particular important feature of strata, for example reservoir presence. An example is presented to illustrate how this works and why it is particularly useful.

HIGH RESOLUTION STRATIGRAPHIC INTERPRETATION AND MODELING OF THE LEEWARD PROGRADING WESTERN BAHAMAS SLOPE DURING THE PLIO-QUATERNARY

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The western slope of the Great Bahama Banks (GBB) is a remarkable setting to study the links between slope sedimentation and failure triggering. Slope failure events affecting the slope and margin deposits are observed during the whole Plio-Quaternary interval. They are associated with changes in geometries and material in the slope under internal and external factors. Several oceanographic surveys provided good insights on the depositional processes during the Holocene and Late Pleistocene. The GBB subsurface has also been well investigated by successive oceanographic cruises that notably collected a complete 2D seismic transect from platform to basin and drilled 4 IODP wells on the slope and 2 on the platform. The integration of these datasets allows us to build a detailed facies model of this section, based on well information and seismic facies, integrated into a sequence stratigraphy framework at the resolution of the MIS stages for the last 0.5 Myr. We compare it with a 2D forward stratigraphic DionisosFlow simulation at a 10 Kyr resolution. Thus we can evaluate the possibility for the current models of sedimentary processes to account for the observed depositional geometries. Understanding and simulating the depositional history and geometries provides a framework to compute the mechanical stratigraphy and assess the slope stability through time.

Since 2.6 Myr, the GBB platform has evolved from a ramp toward a reef rimmed platform and a flat top bank. The depositional regime between 2.6 and 1.7 Myr was marked by a forced regression of the platform margin and deposition of large debrites at the toe of slope. Then from 1.7 Myr to the present the system evolved by progradation then aggradation of the platform, and by accumulation of successive muddy wedges on the slope. During the Late Pleistocene, the large sea-level fluctuations controlled the erosion of the platform margin and the formation of cemented layers on the slope during lowstands. Highstands are dominated by the export of platform mud toward a slope wedge, bypassing the steep uppermost slope escarpment (0-200 m mbsf). This sedimentological model cannot explain the progradation of the platform margin observed in seismics during the whole Pleistocene.

On a leeward margin, the observed progradation relates to the interplay of mud production and export from the inner platform, and the accumulation of lithified reefal material along the margin. With the DionisosFlow simulations we test hypothesis for sediment production and export. It allows weighting the influence of external environmental factors like sea-level variations and sea-current initiation against internal factors like the carbonate production controlling the geometry of the slope. The resulting oversteepening and overloading on the platform and the slope controls the triggering of sporadic failure events. The stratigraphic model calibrated by the interpreted section is used in an integrated forward numerical workflow of slope failure modelling. It describes at a 10 kyr scale the geometry of early cemented layers and large highstand sedimentary loads through time, controlling the slope stress and fluid overpressure state.

INVESTIGATING CONTROLS OF GRAVITY FAILURES ON CARBONATE SLOPES: FORWARD NUMERICAL MODELLING OF MECHANICAL STRATIGRAPHY

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Carbonate slopes show gravity-driven failure events that reflect environmental and depositional changes with time on the carbonate platform and upper slope. Processes controlling these events have been conceptually proposed but have rarely been quantitatively studied. Integrating slope stability analysis in forward stratigraphic models can bring new developments on the relationships between the failure events and the stratigraphic evolution of the slope.

This presentation is an application of a forward numerical workflow for slope stability evaluation, based on an explicit description of the mechanical state of the slope. We call this numerical description the "mechanical stratigraphy": it integrates the genetic link between the stratigraphy and the mechanical properties of the sediments. It includes the porosity, the fluid pressure and the strength of the sediment for each space cell and time step of a 2D stratigraphic section. The combination of these variables determines the most probable failure mechanism and the slope state of stability. This model allows us to decipher the interaction between the evolution of the slope and the failure events during its depositional history.

This workflow was applied on a 2D section of the Western slope of the Great Bahama Bank (GBB) during Pliocene and Quaternary times. Large scale failure events (0.110 km^3) have been described during these time periods. The large seismicand well dataset in the geographical area, including dating, makes it a well-constrained analogue. The timing of failure events has been related to the Pleistocene sea-level variations, especially during sea-level falls. Early cemented layers, for instance associated with Pleistocene lowstands, have also been proposed as a pre-conditioning factor. These internal and external factors are integrated in our workflow to quantify their capacity to localize or trigger a slope failure.

The first simulation stage is the forward stratigraphic modeling with DionisosFlow to obtain a high time resolution (10 kyr) 2D geometry and facies description of the platform-basin depositional system. This stratigraphic model for the Plio-Quaternary sequences is compared with a detailed interpretation of the seismic section calibrated with wells. Secondly, the computation of the evolution through time of the mechanical stratigraphy with the TemisFlow basin modeling software is made. It includes compaction and permeability laws deduced from experiments on sediment samples and well data collected in the literature.

Our results indicate a strong control of the mechanical stratigraphy by the depositional geometry and associated sedimentation rates. They are controlled both by the environmental parameters and the carbonate production on the platform. The increased carbonate production exported to the slope generates transient fluid overpressure during higstands. Conversely, lowstands are marked by the overpressure dissipation on the slope. Overall the fluid overpressure values obtained are low and cannot explain the observed instabilities on the slope of the GBB. The strength contrasts associated to early cemented materials appear as an influent pre-conditioning factor. The mechanical stratigraphy can be used in a further step of computation of the slope failure mechanism. External trigger factors as earthquake or upward motion of fluids could be integrated into more advanced analysis of slope failure.

ANALYSIS OF STORM-GENERATED FACIES IN TRIBUTARY-JUNCTION FANS: THE MARCH 2015 DEBRIS FLOWS EVENT IN EL HUASCO RIVER VALLEY, NORTHERN CHILE

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The rainfall that affected the mountain ranges of the Atacama Desert, in northern Chile, during March 2015 represent, with excellent outcrop examples, an exceptional laboratory to study and document the sedimentary response after a storm especially on the formation of tributary-junction fans. Here, we present the observations for El Huasco River valley carried out the days after the March 2015 storm. The debris flows triggered by this storm are mapped and sedimentologically described in different alluvial fans of this river system. Five facies types are recognized in the alluvial fan sedimentary environment which indicate the changes in water: sediment ratios during the storm. This allows us to comprehend the formation sequence of alluvial fans in an arid environment after one storm.

The formation of tributary-junction alluvial fans contributes on the Holocene evolution of the rivers that drain the western slope in the northern Chile. This assess previous interpretations of the sedimentary environments defined in these valleys where the relations between tributary-junction fans and rivers have been used as a proxy for paleoclimate reconstructions during the Holocene.

DID THE LATE PLIOCENE-EARLY PLEISTOCENE VILAMA FM. SEDIMENTATION RECORDED AN INCREASE OF ARIDITY IN THE ATACAMA DESERT ? INSIGHTS FROM STRATIGRAPHY AND MAGNETIC PROPERTIES

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During late Pliocene until the mid-Pleistocene the lacustrine sedimentary record in the Atacama Desert basins have provided relevant paleo-climatological data to understand climate variations in the driest desert of the world. Some of this work has been carried out in the Quillagua Basin and in the Calama Basin indicating that the largest lacustrine development spanned the 6-3 Ma period. The latest wet period defined in the Atacama with lacustrine sedimentation starts at 3 Ma in the Calama basin (Chiu-Chiu Fm.) and in the western portion of El Salar de Atacama with the Vilama Fm. (Evenstar et al. 2015 and references therein). Here, the lacustrine sedimentation spans from 5.42 Ma until 2 Ma. The Vilama Fm. records different lithologies ranging from: volcanic products (ignimbrites, ash layers), lacustrine carbonates, alluvial fan facies associations (proximal to distal facies) and ephemeral lakes. The basin infilling is controlled by regional climate conditions in the Central Atacama until 3 Ma, then shifting to more likely local climate conditions, tectonics, sediment supply and lately the geomorphic evolution due to the actual landscape configuration.

Evenstar et al. (2015) presented a conceptual model for the Vilama Fm. where the stratigraphic relations are presented. Nevertheless, the coeval carbonate sedimentation of mudstones in the western region with the marls in the east is not easy to prove it because a topographic high, La Cordillera de la Sal mountain range, separates depocenters in the west with depocenters in the east until at least 3.7 Ma.

Our work aims to provide detailed stratigraphy which includes the magnetic properties of the sediments for both sides of La Cordillera de la Sal. To fulfil this mission, two stratigraphic logs (1:100) were performed and sampled for magnetic properties. The total magnetic susceptibility of sediments was measured and hysteresis curves, IRM and S-IRM were performed using an alternating gradient magnetometer for both sedimentary logs. Preliminary results delineate variations from the ferromagnetic phases which might help to accurately establish the initial environmental conditions and those prevalent during diagenesis. Current work is being carried out in the field and will consider new geochronological data.

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METHANE-DOMINATED BSR AND TSR ORIGINS FOR HIGHLY ^{13}C-DEPLETED CAP DOLOSTONE CEMENTS

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Calcite veins with $\delta^{13}C$ down to 48‰ from the Ediacaran Doushantou Formation cap dolostones (ca. 635 Ma) overlying the glaciogenic diamictite of the Cryogenian Nantuo Formation are explained as the result of anaerobic oxidation of methane coupled with sulfate reduction, or bacterial sulfate reduction (BSR), in hydrothermal fluids with $\delta^{18}O_{SMOW}$ values of about +13 to +18‰ at about 275°C, over which, however, no SRB can survive. In order to solve the puzzle, we carried out petrological observations and carbon and oxygen isotopes analyses and collated sulfur isotope data from Zhou et al. (2016) on 85 cm thick carbonates immediately above the cap dolostone in the Jiulongwan section, South China. The limestones are about 35 cm thick and composed of calcite, dolomite, volcanic glass and clasts and pyrite. Three generations of calcite are identified. The earliest calcite is blocky spar with well-developed cleavage and shows dark orange luminescence, some of which show pseudocrystals after anhydrite or barite. Micro-drilled powders from this calcite mixed with finely crystalline dolomite have $\delta^{13}C$ values from -3.4 to -26.4‰ and $\delta^{18}O$ values from -2.1 to -8.8‰ (n=12). The sample with the lightest $\delta^{13}C$ and $\delta^{18}O$ value contains the least dolomite and is calculated to precipitate at 62°C from the seawater ($\delta^{18}O_{SMOW}$=0‰) using the equation of O'Neil et al. (1969) (1000lna=2.78(10^6/T)-2.89). The second generation of calcite is coarse crystalline and light orange luminescence, occurs as fracture-fillings and shows $\delta^{13}C$ values from -5.6 to -50.7‰ and $\delta^{18}O$ values from -7.8 to -14.9‰ and have fluid inclusion temperatures from 100 to 152°C with an average of 138°C, among which the lightest calcite is measured to have FI temperature of 139°C and is calculated to precipitate from a solution with a $\delta^{18}O_{SMOW}$ value of 8.6‰. The third generation of calcite occurs as fine veins crosscutting the two generations of calcite and dolomite. Dolomite is silt-sized and non-luminescent. Pyrite is abundant and have $\delta^{34}S$ values of 37.0 to 41.4‰ in the limestones, being very close to those of the carbonate associated sulfates (CAS), and have $\delta^{34}S$ values of 19.2 to 29.5‰ in the overlying 50 cm dolostones. These data indicate that the there exist earlier bacterial and latethermochemical sulfate reduction by organic matter atabout 60°C and 140°C, respectively, to generate ^{13}C-depleted calcite and ^{34}S-rich pyrite. Methane is one of the most likely reactants, especially for the TSR, and may have derived from the Cryogenian Datangpo Formation shales underlying the Nantuo Formation. Brines may have up-migrated along with hydrocarbons from the Datangpo Formation shales, which host a main level of manganese deposits in the Yangtze Platform, resulting in high Mn/Sr (>100) and $^{87}Sr/^{86}Sr$ ratios (up to 0.713) for the calcite cements. We propose that the strata did not experience heating and diagenetic alteration by hydrothermal fluid with temperatures > 200°C as suggested by Bristow et al. (2011) based on clumped isotope thermometer, which may have overestimated diagenetic temperatures as the result of solidstate resetting under a low water/rock ratio.

CLIMATIC AND EUSTATIC CONTROLS ON TERRESTRIAL ORGANIC MATTER SEDIMENTATION IN A DEEP MARINE BASIN: A MULTIPROXY APPROACH ON THE OXFORDIAN TERRES NOIRES FORMATION, SUBALPINE BASIN, SE-FRANCE

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Our aim is to investigate the processes controlling the sedimentation of organic matter (OM) in deep marine basins using a multiproxy approach (clastic-fraction grain-size, Rock Eval parameters, elemental composition, clay-mineral assemblages, molecular biomarkers), to assess the way continental OM is distributed along a proximal-distal transect. For this purpose, the focus was set on the part of the Terres Noires Formation dated of the Early and Middle Oxfordian in the Subalpine Basin. This formation presents a very thick marl accumulation (1800 m at the maximum) yielding low OM content (TOC = 0.5 to 1%) deposited in a hemi-pelagic environment. A total of 53 samples of dark marls picked in the Oze and Trescléoux sections (~ 300 m thick) were analyzed, the sections corresponds to a third order eustatic sequence of ~ 2 Ma. The results show a shift of the sedimentary and organic records at the Early to Middle Oxfordian transition (EMOT). A progressive decrease in OM content is observed from ~ 0,8% for the Early Oxfordian to ~ 0,5% for the Middle Oxfordian. The Tmax drops from 455°C to 443°C during the EMOT. Moreover, a marked decrease in the terrestrial OM input is highlighted by the decreasing proportion of carbohydrate-and ligninderived molecular compounds (des-and methyl-dibenzofurans). Grainsize analyses indicate a weak variation of hydrodynamic energy during the EMOT, in addition to a gradual transition from kaolinite + illite-smectite mixed-layersdominated to illite + chlorite-dominated clay mineral assemblages. Furthermore, redox-sensitive trace elements indicate well-oxygenated depositional conditions during the Early-Middle Oxfordian.

According to these results, we propose that:

1) During the Early Oxfordian, the combination of a more humid climate on land and a global low sea level have furthered the continuous production and discharge of continental organic matter in the deep basin.

2) On the contrary, during the Middle Oxfordian, more arid conditions and the rise of global sealevel limited the production and transport of terrestrial OM to the deep basin.

This multiproxy approach evidences the role of the climatic and eustatic controls on the sedimentation of land-derived OM in a hemi-pelagic basin. Our result allows us assessing the background contribution of continental OM and the results are transposable to other basins, where marine productivity superimposes to allochthonous supplies.

SEDIMENTOLOGY AND CLIMATE EVOLUTION IN THE EASTERN REGION OF CENTRAL AFRICA DURING THE PERMIAN-TRIASSIC: AN EXAMPLE OF THE LUKUGA GROUP IN THE ORIENTAL PART OF THE CONGO BASIN

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In the eastern region of the Central Africa, the Karoo rift system is contemporaneous of the Permian-Triassic transition. In this area, the sediments, observed at outcrop and in sub-surface, have recorded several changes of climatic conditions between the late Carboniferous and the Triassic. In order to refine the sedimentology and the depositional environments of the Karoo rift sediments in the eastern region of Central Africa, three cores from the Lukuga Valley (eastern part of the Congo Basin, Democratic Republic of Congo) have been described. These cores are available at the Royal Museum for Central Africa (MRAC/KMMA, Tervuren, Belgium), and they correspond to the upper part of theLukuga Group (Permian) and the HauteLueki Group (Triassic) in the Congo Basin. Fifteen lithofacies have been identified, which permit a reinterpretation of the depositional environment and paleogeography of these groups in this area. The sandstones of the upper part of the Lukuga Group are interpreted to represent a braided river system, followed by sandstones, mudstones, and coals deposits, which correspond to a shallow, perennial, sand-bed braided river with an extensive flood plain. The top of the Lukuga Group is marked by the return of a braided river system. The Haute-Lueki Group is characterized by the paleosols deposits (red sandstones and mudstones), which are interpreted as a semi-perennial fluvio-lacustrine system, followed by a semi-perennial fluvial system at the top of the group. The upper part of the Lukuga Group was deposited in a humid to temperate climate, while the Haute-Lueki Group was deposited in a more arid climate, with periods of emersion. These unpublished results are compared with: 1) the deep boreholes in the central part of the Congo Basin; 2) the historical studies in the oriental part of the Congo Basin, along the shore of Lake Tanganyika; and 3) the Karoo rift basins in the western part of Tanzania (Ruhuhu Basin, Galula Basin, and Songwe-Kiwira Basin) and in the north-eastern part of Zambia (Luangwa Basin).

This compilation permits to build the following climatic evolution between the end of Carboniferous and the Triassic in the eastern region of the Central Africa: 1) a cold and semi-arid to temperate climate during the end of Carboniferous, through the deposition of glacio-lacustrine and periglacial lacustrine sediments; 2) a hot and humid to semi-humid climate during the Permian, as evidence by the swampy fluviolacustrine and lacustrine environments; and 3) the persistence of a hot and humid to very-humid climate during the Triassic, through the occurrence of the paleosols, which indicated the semi-perennial lacustrine, fluvio-lacustrine, and fluvial environments.

STRUCTURAL ARCHITECTURE AND TECTONIC INHERITANCE OF THE MARAÑON AMAZONIAN FORELAND BASIN (NORTHERN PERU)

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In the Northern Peru region, the Huallaga-Moyobamba Maranon subandean foreland basin system results from the interaction between thin and thick skinned tectonics. Geophysical data and the construction of two balanced cross section show that this structural configuration has been controlled by Permian inheritances. A fossilized west verging Middle Permian fold and thrust belt, which developed during the Gondwanide orogeny, has been partly reactivated by the Andean compression and controlled thick skinned tectonics propagation. This west-verging thrust system is still active and causes the crustal and damaging seismicity of the Moyobamba region. Late Permian salt, which has sealed the Middle Permian fold and thrust belt, controlled thin skinned tectonics propagation and the development of the must large over thrust of the Peruvian subandean zone. The fossilized and partly reactived Middle Permian fold and thrust belt constitutes a new petroleum play for the exploration in the northern Peruvian subandean basin. Sub-thrust traps of the Moyobamba and Huallaga wedge top basins are particularly attractive but stay unexplored.

HIGH CONCENTRATION OF CARBONATES IN THE NORMANDY-BRITTANY GULF (ENGLISH CHANNEL): A NEW MODERN CARBONATE DEPOSITIONAL MODEL OF TEMPERATE SHALLOW SEAWAY?

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The Normandy-Brittany Gulf (NBG), which is located in the central part of the English Channel, is characterised by surficial sediments showing carbonate content varying from 30 to near 100 %. Such a high concentration in carbonate particles results from a combination of six main parameters.

Water depths in NBG rarely exceed 60 m with an average value around 30 to 20 m. This shallow subtidal environment typically represents a depositional ramp setting with gradual deepening trend toward open sea.

The 230 km-long coastline of NBG includes several estuaries of small rivers with very low terrigenous sediment discharge. As a result, seawater remains clear with only few high turbidity zones that are restricted to the estuary vicinity. The input in detrital sand and clay fraction in the NBG is considered as very low except near the coastal embayments (Mont-Saint-Michel & Saint-Brieuc bays) and rias (Rance estuary).

Several carbonate producers such as bivalve or gastropod communities and red algae accumulations live in surficial sediments. A large part of the in-situ carbonate fraction is directly derived from this thriving and highly diverse carbonate-producing biota. The tidal wave penetrating the English Channel seaway is amplified in the NBG by the Cotentin Peninsula acting as a baffle. The resulting megatidal regime creates strong and continuous currents, which actively disintegrate the carbonate shells and tests by mechanical action.

The large-scale corner-shape of the NBG coastline results in a dead-end depositional setting, which favours trapping of sediments as well as several marine carbonate communities. Local hydrodynamic trapping is further enhanced near the numerous islands and subtidal rocky platforms, which generate gyres. The largest bioclastic carbonate bodies in NBG are deposited near the centre of the gyres by sediment trapping. The NBG is characterised by modern sedimentation where both heterotrophic molluscs (bivalves & gastropods) and phototrophic red algae producers control the nature of the carbonate-rich shallow water sediments. This warm/cool temperate depositional model results from a combination of circumstances (the above six parameters), which have not been reported elsewhere: as such this depositional model may represent a new type of heterozoan carbonates, which deserves to be tested for interpreting recent or fossil non-tropical carbonate series.

SEISMIC IMAGING OF MESSINIAN EVAPORITES IN THE IONIAN BASIN

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The understanding of the Messinian Salinity Crisis (MSC) as a Mediterranean basin-wide event requires an improved knowledge of the stratigraphy in the deep basins and continental margins. The seismic markers of the deposition of Messinian evaporites in the deep Mediterranean basins identify two end-members in the Western Mediterranean basins and in the Levant Basin. In the Western Mediterranean a consistent succession of three seismo-stratigraphic units in the deep basins, the so called seismic trilogy, can be correlated across thousands of kilometers in the Algero-Balearic and Provençal basins with a fairly constant distribution of the Lower Unit, the Mobile Unit, and the overlying Upper Unit. In the Levant Basin, one single seismostratigraphic unit defines the MSC, composed of up to 6 alternations of a transparent and layered seismic units. The causes of these different seismic expressions of the MSC are presently under investigation.

Here we report on the seismic signal analysis performed on vintage multichannel seismic reflection profiles from the Ionian Basin, that is located immediately down-flow from the sill separating the Western Mediterranean Basins and the Levant Basin during the postulated re-flooding of the Mediterranean at the end of the MSC. Given the intense post-Messinian tectonic deformation induced plate convergence below the Calabrian and Hellenic margins, the challenge in this area is the identification of an undisturbed deep sea evaporitic sequence where the data quality allows a reliable reconstruction of the seismic units. With the aid of a extensive velocity analysis and pre stack migration in time and depth domains, we have been able to define a third type of deep basin Messinian seismic sequence characterizing the Ionian Basin. This is composed by a very thin (one or two high amplitude reflectors) and discontinuous Lower Unit, that makes up basal lens-shaped bodies overlain by a nearly 1 km-thick Mobile Unit, typically composed of a transparent seismic appearance, overlain by a relatively thin Upper Unit composed of regular package of high amplitude reflectors. The existence of this seismic expression of the MSC in the deep basins reinforces the evidences for a longitudinal differentiation of the MSC across the Mediterranean basin, the causes of which cannot be fully understood without sampling the deep Mediterranean evaporites in different locations.

VARIATIONS ON FLUID CHEMISTRY DURING THE FORMATION OF CU-EXOTIC DEPOSITS REVEALED BY BANDING TEXTURES OF CHRYSOCOLLA

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Chrysocolla is a Cu-bearing hydrated silicate mineraloid whose chemical composition contains a varying substitution of elements and water content, being Cu^{2-} (Al^{3+},Fe^{3+}) H^{2-} [SiO](OH) nH_2O the most commonly accepted formula, which takes into account the substitutions of Cu by Al and/or Fe^{3+} and the addition of H_2O. The X-ray diffraction patterns of chrysocolla indicates an amorphous to poorly crystalline material that mostly occurs as opaline, botryoidal or globular masses. The most outstanding characteristic of chrysocolla is the rhythmical banded texture revealed by different colour from green to deep blue. Occasionally microcrystalline quartz, opal or calcite layers follow this succession. Precipitation of chrysocolla occurs in the supergene profiles related to copper depositsthe source of the metalswhen topographically driven groundwater flow promote the lateral migration of Cu-bearing solutions that will deposited chrysocolla in the surrounding paleo drainage network as interstitial cement in permeable sedimentary sequences or filling fractures and pores in basement rocks. The precipitation of chrysocolla is comparable to a silicification processes mainly controlled by the pH of silicifying solution, the Si concentration and, especially in arid climates, evaporation. On this process, oversaturated solutions precipitate soluble and disorder species (chrysocolla), then each chrysocolla band could represent a different mineralizing fluid. The transition to microcrystalline quartz or opal and calcite responds to a progressive pH rise and the depletion first of Cu and later of Si. The absence of well-developed quartz crystals could indicate a high evaporation rate that rapidly increased the pH towards a value of ~9. At this point, silica could no longer precipitate and carbonate became stable.

EDS and QEMSCANR ® analyses on chrysocolla indicate the occurrence of Mg, Al, Ca, Fe, K, S and Cl as minor elements. In any given chrysocolla mineralisation some or all of these elements may be present at various concentrations. Consequently, numerous sub-classifications are required to accurately account for the variety of possibilities for any given chrysocolla, especially during QEMSCANR ® analysis, to enable textures to be usefully identified and mapped. On BSE images, the changes in colour tone of millimetre-scale banding is primarily correlated with variations in element concentrations, consistent with the Cu/Si ratio map, darker bands have a lower Cu/Si ratio, whilst brighter bands have a higher Cu/Si ratio. It is also probable that the variation in minor elements, such as Al, may enhance these observed changes. In addition, there are “speckled” bands with “cloudy” appearance within the chrysocolla that contain micron sized SiO_2 inclusions. This raises the possibility that the Cu/Si variations within could be an artefact of the presence (or lack of) (sub) micron-scale silica inclusions.

There is a close relationship between different colour tones of chrysocolla with variations of chemical composition. The typical colour variations display sharp contacts, implying relatively sudden changes to the composition of the mineralising fluids over time. Given the scale of the bands, these changes occurred often and regularly. Further trace elements analyses will provide new insights on the variation of fluid composition and changes on environmental conditions during chrysocolla precipitation during formation of exotic-Cu deposits.

UNVEILING COASTAL AEOLIAN FACIES IN THE UPPER JURASSIC RECORD OF EASTERN IBERIA: NEW INSIGHTS FROM THE DINOSAUR FOSSIL–BEARING VILLAR DEL ARZOBISPO FM (TERUEL, E SPAIN)

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The Upper Jurassic Villar del Arzobispo Fm is a mixed siliciclastic-carbonate succession that crops out in the Riodeva area (Teruel, eastern Spain) and preserves abundant dinosaur fossils. In this area, the succession has been interpreted as representing the preserved accumulation of an inner carbonate platform that evolved upwards into a predominantly siliciclastic fluvial system with minor marine carbonate incursions. However, preliminary studies performed in this area have revealed the presence of aeolian deposits intercalated with tidal, scarce alluvial and marine deposits, suggesting deposition in a coastal plain setting, rather than a fluvial system. In this work, we analyse the aeolian deposits of the Villar del Arzobispo Fm to reconstruct the depositional environments of the unit. For the first time, we describe the occurrence of dome-shaped aeolian dunes in the Mesozoic record of Iberia. The studied deposits are arranged in metre-thick sandstone beds (up to 10 m). Beds exhibit flat bases and tops, and a lateral continuity up to 300 m and occur interbedded with edaphized, reddish siliciclastic mudstone. Two facies associations are distinguished.

The Aeolian dune facies association consists on fine-to medium-grained, well-to very well-sorted sandstone, which displays different types of large-scale cross-bedding. (1) Tangential cross-bedding is arranged in up to 2 m-thick sets, displaying tangential foresets (angles of 20-35°) and reactivation surfaces; internally, it is formed by mm-to cm-thick laminae that pinch out upwards and downwards. (2) Low-angle cross-bedding is arranged in sets up to 2.7 m-thick, displaying low-angle foresets (< 15°), laterally extensive bottomsets and reactivation surfaces; internally, it consists of mm-to cm-thick laterally continuous laminae. (3) Dome-shaped cross-bedding is arranged in up to 4 m-thick sets, consisting of convex-up, steeply dipping foresets (up to 35°) with preserved topsets.

These features are typical of migrating aeolian dunes. Specifically, the tangential cross-bedding may result from the accumulation of grainflow packages on the lee side of dunes exceeding the angle of repose, whereas the low-angle cross-bedding may result from the accumulation of wind ripples in the dune plinths. Deposits displaying steeply dipping, convex-up foresets with preserved topsets are interpreted as dome-shaped dunes.

The Interdune facies association comprises two facies. (1) Near-horizontally laminated sandstone with mm-to cm-thick layers of carbonaceous detritus occurring as drapes; these drapes commonly pass updip into the bottomsets and rarely the lower part of the foresets of aforementioned aeolian dune deposits. (2) Decimetre-thick, fine-grained, climbing-rippled sandstone beds, interbedded with tangential cross-bedded sandstone.

These facies suggest deposition in wet aeolian interdunes that were subjected to episodic aqueous floods. The fact that the studied deposits are interbedded with tidal and marine deposits, suggests that interdune flood events might have been caused by storms or spring tides in this coastal palaeoenvironment. Ephemeral flash flood events likely also occurred. Collectively, these facies relationships indicate that, during the Late Jurassic, coastal aeolian dunes developed in a coastal plain setting in eastern Iberia; this plain was also influenced by tides and affected by episodic alluvial deposition.

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MINERAL DATING AND THE IMPACT OF MANTLE-DERIVED CO_2 CHARGING ON THE RESERVOIR QUALITY OF THE LOW CRETACEOUS QUANTOU FORMATION TIGHT SANDSTONES IN THE SOUTHERN SONGLIAO BASIN, CHINA

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Dawsonite, the indicator mineral for CO_2 charging, is common in the Late Cretaceous Reservoir of the southern Songliao Basin. To identify the origin of dawsonite, the carbon isotope ratio of CO_2 gas in equilibrium with the dawsonite during the formation of dawsonite was calculated. The $\delta^{13}C$ values of the dawso nite in the study area range from -3.8‰ to -2.6‰, and the calculated $\delta^{13}CCO$ in balance with the dawsonite is -9.8‰ to -8.74‰, which is inside the range of $\delta^{13}CCO$ of CO_2 (-2‰ to -10‰) in the southern Songliao basin. CO_2 in the souther Songliao Basin is mostly originated from mantle-derived magma, therefore, so is the carbon source of dawsonite in the study area. The time of mantle-derived CO_2 charging is identified on the basis of paragenetic sequence and fluid inclusions. There are two periods of hydrocarbon charging, and the mantle-derived CO_2 charging occurred slightly or later than or quasi-simultaneously with the second hydrocarbon filling. During the early charging of mantle-derived CO_2, the pore fluid environment in the sandstones turned acid which resulted in the dissolution of unstable detrital grains, especially the dissolution of plagioclase and potassium feldspar which can provide Na^+ and Al^{3+} ions for the precipitation of dawsonite. Accompanied by the increasing concentration of alkali metal ions and CO_2 partial pressure in the pore fluids, the fluid environment turned alkaline – weakly acidic, and then the precipitation of dawsonite occurred. The former leads to the formation of secondary pores which can improve the reservoir quality, while the latter will destroy the reservoir quality because the dawsonite are mostly intergranular pore-filling cements. The CO_2 charging is harmful to the reservoir quality when the dawsonite content exceeds a threshold of 5%.

PETROGRAPHY AND PROVENANCE OF SILT. AN EXAMPLE FROM THE MESOZOIC MANDAWA BASIN (TANZANIA)

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Provenance analysis has traditionally focused on the sand fraction which is generally preferred to conglomerate (too proximal to the source) and silt (too far away from the source) as they both allegedly provide limited information. However, is important to recognise that the silt transported in suspension represents most of the sediment transported by large river systems and the predominant grain-size in major deltas and submarine fans, as well as in most of ancient sedimentary basins and reservoirs. The standard routine to determine the composition of silt and clay fractions consists in the application of a series of geochemical techniques to analyse major and trace elements and REE (Rare Earth-Elements). Data are then generally plotted onto tectonic-setting discrimination diagrams and parent rocks are generically identified only in terms of mafic or felsic affinity. Many studies have demonstrated that these plots can be inaccurate. Furthermore, the traditional approach is limited by the incorrect assumption that silt-sized sediments are refractory and not affected by diagenesis. A sophisticated separation technique and the combination of optical analysis, RAMAN spectroscopy and quantitative X-Ray power diffraction is used to quantitatively determine the composition of silt (both low-density and high-density minerals). This technique has been successfully applied to determine the provenance of Upper Jurassic-Cretaceous silt-sized sediments exposed in the Mandawa basin of southern Tanzania. The analysis of main framework minerals identifies quartz as the dominant phase (Q83-41K25-17P37-0). Among feldspars, K-feldspar dominates on plagioclase and they both increase through time. Heavy mineral concentration (HMC) varies between 0.2% and 2.3% with values increasing from the northern to the southern parts of the basin. Garnet and apatite are the most common minerals together with durable zircon, tourmaline and in minor amounts rutile. Accessory but diagnostic phases are titanite, staurolite, epidote, monazite and glaucophane. Etch pitches on garnet and cockscomb features on staurolite document the significant effect of diagenesis on the pristine heavy mineral assemblage. Multivariate statistical analysis highlights a close association for garnet-apatite, moderate for titanite-epidote and, not surprisingly, a close one among durable minerals (zircon, tourmaline and rutile, ZTR). The garnetapatite association is particularly meaningful for Upper Jurassic samples, whereas the ZTR association characterizes the Jurassic-Cretaceous boundary. Upper Cretaceous samples are enriched in titanite and epidote. U-Pb dating of detrital zircon and RAMAN determination of garnet type and their statistical integration with the above mentioned datasets provide further insights on provenance and/or drainage patterns eroding the Archean/Proterozoic highgrade gneiss/schist in the Late Jurassic, the Paleozoic continental sediments at the Jurassic-Cretaceous boundary and Proterozoic phyllite and schists during the Late Cretaceous. The obtained results are discussed in the light of potential application of this technique to the hydrocarbon industry.

NEW CHARACTERIZATION OF THE EARLY TRIASSIC SONOMA FORELAND BASIN (WESTERN USA) AND ITS CONTROLLING FACTORS USING MULTI-SCALE INTEGRATED APPROACHES

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In the aftermath of the end-Permian mass extinction (~252 Ma), the Early Triassic Sonoma Foreland Basin (SFB) provides excellent sedimentary and fossil records to describe and understand the Early Triassic biotic recovery. Nevertheless, despite its importance, this basin is still poorly constrained and its controlling factors rather unclear. A new multi-disciplinary and integrated study is proposed based on ~50 sections from the literature and field-based data. Sedimentary, geochemical, paleontological, geodynamical and structural analyses have been conducted at various scales, from the section to the entire basin. Based on a high-resolution biostratigraphic framework, SFB depositional settings and their paleogeographical distribution are reconstructed, as well as their spatio-temporal and geodynamical evolutions.

The SFB sedimentary record allows to characterize several facies associations representing depositional settings laterally evolving from transitional continental to intertidal tidal flats and high energy shoal, and to open marine outer platform settings. Nevertheless, marked differences are documented between the northern and southern parts of the SFB. Indeed, the sedimentary record shows differences in lithology and in spatial distribution of the sedimentary thicknesses. These observations are also reflected in the paleontological record, displaying the presence or absence of several biotic assemblages such as microbial communities. Microbial limestones are mainly restricted to the southern SFB while siliciclastic microbially induced sedimentary structures are locally observed in the northern part. Moreover, geochemical analyses indicate a spatially-heterogeneous influence of secondary alteration over the carbon isotope signals. In the southern part of the SFB, this record is highly altered and does not reflect the primary sedimentary signal. Conversely, the northern part of the basin shows a "pristine" sedimentary signal, representative of the ocean-atmosphere system.

These North/South differences can result from processes interacting at different scales. On the one hand, at the basin scale, we notably show that heritage of the ~2 Gyr-long tectono-sedimentary history of the SFB is reflected in marked regional differences in subsidence rates. On the other hand, controls such as the geochemistry of the water column or terrestrial influxes have influenced the local evolution of the depositional settings. To sum up, we highlight a complex interplay of local to basin-scale controlling factors over the spatial distribution and lateral migration of depositional settings observed in the SFB and demonstrate that two sub-basins should be considered within the Early Triassic Sonoma Foreland Basin.

IMPORTANCE OF THE LOCAL CONTROLLING FACTORS OVER THE EARLY TRIASSIC PAIRED CARBON ISOTOPES FLUCTUATIONS

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Important and recurrent perturbations of the carbon isotope signals are recorded during the Early Triassic, in the aftermath of the end-Permian mass extinction (~252 Ma). These perturbations, among the largest observed throughout the Phanerozoic, are most notably represented by a globally recognized couplet of a negative and a positive excursions, before and across the Smithian/Spathian boundary (SSB, ~1.5 Myr after the Permian/Triassic boundary), imprinted in both the carbonate and organic matter reservoirs. These fluctuations are generally assumed to be linked to environmental perturbations related to a late degassing of the Siberian Traps. Recent works on the Early Triassic Sonoma Foreland Basin (western USA) have shown that local secondary processes can have a strong influenceon the carbon isotope record, preventing its usual use for long-distance correlations and global climatic interpretations. Here, new measurements of paired carbon isotopes (carbonate and organic matter fractions) from the Griesbachian-Dienerian up to the lower Spathian have been performed on a section of the Sonoma Foreland Basin, at Hot Springs (SE Idaho).

We show that both carbonate and organic matter $\delta^{13}C$ signals mirror the signal recognized at the global-scale, particularly for the SSB event, and that this signal is not due to secondary diagenetic processes. However, if SSB excursions are observed in both signals, dampened variations in the organic reservoir are observed. These variations in the net isotopic effect (i.e., $\delta^{13}C$) reflect a complex set of locally controlled forcing parameters (including, but not restricted to, e.g. mixing of terrestrial and marine organic matters in relation to variation in sedimentary depositional setting), rather than suggested CO_2-driven temperature variations. We argue that even if the globally recognized variations of the carbon isotope record are observed, the Hot Springs isotope signal most probably reflects primarily the local geological context rather than diagenetic or exogenic carbon cycle processes. We therefore question the validity of high-resolution carbon signals for long-distance correlations during the Early Triassic. Rather, we suggest to use the carbon signal to characterize fluctuating local conditions during deposition.

ORIGIN OF SHORE-NORMAL GROOVES (GUTTERS) ON A STEEP SANDSTONE BEACH-FACE

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Shore-normal grooves (gutters) cut into the seabed have been reported widely from the marine geological record. Often grooves are spaced regularly across plane, consolidated surfaces in the littoral and sublittoral zones and may be deeply incised. Despite their common occurrence in the rock record, there are few detailed descriptions of examples from modern environments. The reported examples have been ascribed to erosion by wave-induced currents, especially storm-driven near-shore flows. In particular, examples from beach-faces have been related to either wave swash or backwash. However, no conceptual model exists to explain the presence of grooves, their morphology or their spacing alongshore.

Herein, quasi-regularly spaced grooves on a soft sandstone beach-face are described that it is argued formed due to wave breaking and swash zone processes consequent upon exceptional storms at sea. The groove morphologies are quantified using terrestrial laser scanning. Numerical modelling of the translation from offshore waves to nearshore breaking waves provides estimates of the swash zone parameters. A consideration of swash zone processes provides an explanation for formation of the grooves. In particular, the swash zone shear stress distribution and consequent bed erosion is a dome-shaped function of distance across the beach-face, which function controls the cross-shore variability in groove depths. High-speed sheet flows, such as swash and backwash, develop periodic, shore-normal high and low speed streaks alongshore. Consequent streaky erosion controls the quasi-regular alongshore groove spacings. However, on any given beach-face the specific spacing of grooves is likely a property, not only of the local sheet flow attributes, but also of larger-scale morphological forcing. This outcome suggest that spacing is an emergent property of the coupled sheet flow and larger-scale forcing and specific spacings on any beach-face remain unpredictable.

STRUCTURE AND EVOLUTION OF THE GISSAR CARBONATE PLATFORM (UZBEKISTAN): A RECORD OF PALAEOENVIRONMENTAL CHANGES IN THE NORTHERN TETHYS MARGIN DURING THE MIDDLE AND LATE JURASSIC

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The SW-Gissar range (westernmost part of the Tien Shan) consists of a succession of anticlines and synclines forming a relief between the Amu Darya and Afghan-Tajik basins. Recent fieldwork has been performed to study the development and the architecture of a vast Middle-Upper Jurassic carbonate platform. The studied carbonate series crops out along cliffs overlying Lower to Middle Jurassic continental then marine deposits. Carbonate thickness reaches 500 m in the central and southern Gissar and thins up northwards, near the paleo-border of the Amu Darya Basin. The goal of this study was to build a highresolution stratigraphic framework for these deposits, based on chemo-and lithostratigraphic correlations between seven sections. It was associated with a detailed microfacies analysis in order to establish the spatial and temporal evolution of the palaeoenvironments in this poorly known area. Two major sequences were recognized, (1) Callovian in age, and (2) possibly Oxfordian to Lower Tithonian. The reconstruction of the deposition profile indicates that the Gissar was a gently dipping ramp during the Callovian major sequence. Dark mudstones with entire bivalve and brachiopod shells and oncoids-rich float-to rudstones predominated below and around the storm wave base. Oobioclastic grainstones were deposited in the permanently agitated shallow water zone, while patch and pinnacle reefs built up distally at the inner-mid ramp transition and in the mid ramp. Small shallow water siliciclastic deltas developed close to the emerged lands located in the north. The Callovian sequence is subdivided into seven fourth-order transgressive-regressive sequences. The transition between the two major sequences is marked by a significant change in the carbonate sedimentary system associated with a positive shift in the bulk carbon isotope values. It could record a major climatic change coeval with the Middle-Late Jurassic Transition. Further, it is hypothesized that a sedimentary hiatus exists, possibly caused by the exposure of the platform. The Upper Jurassic major sequence is mostly composed of peritidal deposits, showing rapid vertical and lateral transitions, depicting a more complex architecture. The series consists in numerous meterthick alternations of pellets/algal pack-to grainstone, 'microbial oncoid' floatstone, ooid grainstones and mudstones. These deposits could have accumulated in a vast, mostly aggrading lagoon protected by a barrier reef. Basinwards, close to the Uzbek-Turkmen border, Middle Oxfordian organic-rich algal/microbial carbonates are intercalated within the platform carbonates and could have formed in small stratified and partly isolated intra-shelf depressions. Lastly, a general aridification of the basin could be responsible for the observed increase in gypsum characterizing the upper part of the carbonate platform (Late Oxfordian? to Tithonian?). The numerous oscillations in carbon isotopes evidenced in these evaporite-rich carbonates may be the consequence of high frequency exposure of the platform preceding the deposits of massive evaporite during the Tithonian. This study allows a better understanding of the paleoenvironmental evolution of the northern Tethys during the Middle and Upper Jurassic. Our results will be compared with other Peri-Tethyan Jurassic platforms in order to understand the carbonate platform response to large-scale climatic and tectonic changes occurring at this period.

CHARACTERISATION OF THE INTERNAL STRUCTURE OF HYBRID EVENT BEDS (HEBS) IN DEEP WATER SILICICLASTIC SYSTEMS: FROM OUTCROP TO FLOW MODELLING

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Hybrid event beds (HEBs) are an important component in many deep-water clastic systems. The term 'hybrid' refers to the interpretation that they are deposited from transitional transport events between turbidity currents and debris flows. Their origin is thought to be related to the entrainment and reworking of substrate clasts of prevalent muddy composition by a parent turbidite flow and/or to the progressive concentration of mud in the flow. The resulting HEBs typically contain three depositional intervals, emplaced in a sequence in which turbiditic sandstones sandwich a debrite. The latter is more argillaceous than the associated sandstones and highly variable in terms of thickness, grain size, amount of dispersed clay, sedimentary structures and intraclasts dimension, abundance and clustering

In applied contexts, HEBs impact negatively on reservoir volume (due to the appreciable quantity of clay which reduces the net amount of sand that can be swept economically) and also on reservoir quality (the debritic component may act as a baffle or a permeability barrier to hydrocarbon flow). An important challenge is to develop a better understanding of how complex HEB facies, when present, influence reservoir flow. In this regard, although the general pattern of HEB facies transitions is documented longitudinally and laterally at km or tens of km scale, the impact of short-distance (metre to tens of metre-scale) internal facies changes upon flow is commonly overlooked. Because such complexities modify the overall texture and reservoir characteristics at or beneath typical production well spacing, analogue studies provide the best route to constrain their effect.

Accordingly, this field-based study aims to quantify the physical characteristics inferred to impact on hydrocarbon flow. To date, the database arising from this study includes information on 25 HEBs, found in different ancient deep-water turbidite systems. The studied systems have been selected to sample the full range of HEB types, i.e. from internally complex beds preserving metre-scale substrate rafts to clast-poor beds whose debritic interval is relatively homogeneous. Each HEB has been characterised through the collection of: i) a representative 2D outcrop panel where each sedimentary feature and distinguished sub-facies is represented at centimetre scale, i.e., enabling a satisfactorily representation of the bed for flow modelling purposes to be made, ii) a database of composite vertical thicknesses with a horizontal spacing of 1 m and iii) collection and analysis of high-resolution micro-photographs (50x magnification), allowing the internal texture of each of the internal sub-facies to be distinguished.

The database can be interrogated to quantify: 1) the typical scale of oscillation of the relative proportions of depositional intervals, which can be significant and may even lead to internal lateral pinch-outs; 2) the variability in mud clast arrangement and abundance, and its relationship to 3) the clay content of the matrix, and 4) the frequency and volume of vertical sandy connections between the two sandwiching sands. These data can be used to condition static permeability models of each individual HEB, discretised into cells of homogeneous porosity and permeability values, in which hydrocarbon flow analysis can be performed.

A MODELLING APPROACH COUPLING LANDSCAPE AND BASIN EVOLUTIONS WITH TRACERS FROM SOURCES TO SINKS

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Over thousands to millions of years, the transport of sediment is predicted by models based on fluxes of eroded, transported and deposited material. The laws describing these fluxes, corresponding to averages over many years, are difficult to prove with the available data. On the other hand, sediment dynamics are often tackled by studying the distribution of certain grain properties in the field (e.g. heavy metals, detrital zircons, ^{10}Be in gravel, magnetic tracers). There is a gap between landscape and basin evolution models based on fluxes and these field data on individual clasts, which prevents the latter from being used to calibrate the former. Here we propose a new approach coupling the landscape evolution and basin sedimentation with mobile clasts. Our landscape evolution model predicts local erosion, deposition and transfer fluxes resulting from hillslope and river processes. Clasts of any size are initially spread in the basement and are detached, moved and deposited according to probabilities using these fluxes. Furthermore, these grains dissolve according to their mineralogy, precipitation rate and temperature, so that not only the solid flux but also the weathering flux can be simulated. This model allows the joint dynamics of bulk sediment and the spreading of a given source of grains to be predicted. This approach opens new perspectives including the tracing of sources, the interpretation of detrital geochronological data, the analysis of residence times through the fluvial system, sediment coarsening or fining, and the tracing of weathered sediment.

THE SIZE-DEPENDENT TRANSPORT RATE OF COARSE SEDIMENT DETERMINED USING ^{10}BE IN DISTINCT PEBBLES OF THE AROMA CANYON (ATACAMA, CHILE)

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We focus on coarse sediment routing velocity in fluvial systems. The millennial mean velocity at which coarse sediment move along the fluvial system lies at the heart of many source-to-Sink issues. For example, this velocity determines if a climatic or tectonic pulse of sediment generated in the mountain is advected or diluted towards the basin, and thus if the basin stratigraphy is able to record such variations. Whether this millennial velocity depends on pebble size or not is still unclear. Yet, quantifying this possible size dependence is fundamental to interpret the observed transitions between coarse and fine sediment in basin architecture. These uncertainties result from the difficulty to measure coarse sediment velocities and flux that integrate a wide range of floods over periods longer than several years. Here we show that the ^{10}Be concentrations in distinct river pebbles can bridge this gap. We selected cobbles and pebbles ([0.01-0.3] m) along a ~50 km Andean arid canyon in the Atacama. These samples come from a unique lithological source at catchment head. We obtained the mean ^{10}Be concentrations of ~20 to 100 samples at 7 river stations downstream. In addition, the ^{10}Be concentration of individual pebbles was measured for 3 of these 7 locations. They show a downstream increase of both the mean and scattering of ^{10}Be concentrations. Using a simple stochastic model of grain transport and ^{10}Be evolution, we show that: 1-the millennial maximum mean velocity of ~10 cm pebbles is on the order of several meters by year, and 2-that the velocity is inversely related to pebble size, despite a large variability for a given size. This size-dependence is consistent with the observed downstream fining in this river. Such velocities imply a wide range of residence times ([0.1-100] ka) of pebbles ([0.01-0.3] m) in this arid canyon.

THE MIOCENE FORMATION OF TAVERNA, CORSICA: A MICROPALAEOTONOLOGICAL AND MINERALOGICAL APPROACHE

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Corsica is mostly characterised by granitoids, acid volcanic and metamorphic rocks related to two major tectonic events, the Hercynian and Alpine orogenies. During the early Miocene, a combination of several factors (structural basin inversion, sea-level rise, and subsidence) created the accommodation for a continental and shallow marine sedimentary succession along narrow and elongated basins. Much of these deposits disappeared through time but few scattered outcrops remain, most notably at Saint-Florent and Francardo. The basin of FrancardoPonte-Leccia extends over a distance of 7 km according to a N-S direction along the contact zone between the "Hercynian" and the "Alpine" areas of the island. The Burdigalian – Langhian sedimentary succession is 575 meters-thick, dominantly silicoclastic, scattered occasionally with few carbonate beds and relatively low in fossils. The succession is divided into three rock formations, i.e., 1) the continental series of l'Ortone Formation, 2) the marine neretic series of the Taverna Formation and, at last, 3) the continental series of the Francardo Formation. Here, we re-investigated the Taverna Formation that is about 125 metre-thick and is easily accessible at the quarry of Piedigriggio-Taverna where about 20 meters or so show on the surface.

Using previously collected data by Ferrandini M. and J. and newly sampled data, we performed a micropalaeontological, mineralogical and geochemical analyses of the sedimentary series to better constrain the palaeoenvironmental evolution throughout the available rock succession. A total of 17 levels were sampled for granulometric, mineralogical, (XRD analyses) and phosphorus contents analyses. Additionally, samples were dissolved to analyse their foraminiferal content. Data on species composition and their counts in each sample were collected to characterise fauna evolution.

The lithological analysis shows that the series is composed of relatively well-ordered alternating sequences of conglomerates or puddingstones, sandstones, marl and clay. Analysis of macro-remains of fossils reveals the presence of bivalves, gastropods, crabs (*Colneptunus* sp.), barnacles (*Balanus* sp.), remains of fish (*Aphanius* sp.), and fragments of sea urchins, with locally diversified remains of plants. Few samples were barren of foraminifera. In total, ten taxa or so have been recognised so far, including mostly benthic foraminifera. Planktonic foraminifera are scarce and small in size. In overall, the number of species per samples is low, and the relative abundance of individuals is unevenly distributed within each sample. Relative abundance and species composition of foraminiferal assemblages seem to be constrained by climatic and palaeoenvironmental conditions. Ostracods possess a smooth shell and are scarce.

Lithologic and palaeontological data point to an evolution of the environment from an alluvial plain, through a mangrove and beach stage to a lagoon and finally back to an alluvial plain with a very limited marine episode.

SUBMARINE LANDSLIDES IMPACT ON THE MORPHOLOGY OF THE MOZAMBIQUE CONTINENTAL MARGIN

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The Mozambique margin along the Mozambique Channel is a mixed carbonate/siliciclastic margin. The Zambezi delta is the major source of siliciclastic sediment, whereas almost continuous carbonate reef barriers grew along the outer shelf. The continental slope displays some incisions, but wide areas of open slope dominate. The aim of this study concerns the impact of mass wasting processes highlighted by seafloor morphology on a sector of the outer shelf and the continental slope offshore the Zambezi delta extending about 80 km, 20 km downdip and comprised between 100 and 1100 m wd. The dataset is composed of multibeam bathymetry, backscatter and water column acoustic data acquired with a Reson Seabat 7111 for shallow waters (5-500 m wd, 100 kHz) and a Reson Seabat 7150 for deeper waters (200-6000 m wd, 24 kHz). Data were acquired during the PAMELA-MOZ4 campaign onboard the R/V Pourquoi pas? in 2015 (DOI 10.17600/15000700) within the PAMELA (PAssive Margins Exploration LAboratories) project of scientific collaboration among IFREMER, TOTAL, CNRS, IFPEN, Universities of Brest, Rennes1, Paris6.

A detailed geomorphological map synthetises the main features observable at the seafloor. These include mass wasting features, erosion features (gullies, scours), and fluid-escape features (pockmarks, exhumed chimneys). Reef carbonate flat terraces on the continental shelf break are covered by a continuous sand bar.

Along the slope, two sectors in the study area are identified from NE to SW. The NE sector reveals close to the shelf break numerous fossil isolated carbonate patches. The relatively smooth morphology of the slope displays the presence of pockmarks at the seafloor with active flares imaged by echosounder in the water column but no evidence of seafloor instabilities. The SW sector shows three distinct landslide areas: the East landslide (1 km^3 volume), the central landslide (33 km^3) and the Western landslide (10 km^3).

Landslides show different degrees of deformation with a proposed relative chronology of superposed landslide deposits. The morphologically most pronounced landslide is the central one, with a scar up to 200 m high and large mobilized blocks. In the evacuation area, we suggest the presence of numerous isolated carbonate blocks likely representing the remnant of fluid escape chimneys. It is likely that a link exists between fluid escape processes and seafloor instability. We interpret the observed morphology as a potential expression of variable degree of deformation along the margin in association with fluid escape.

Further data will be necessary to assess the age and dynamics of landsliding along the Mozambique Channel: long sediment cores and in situ measurements (penetrometers and piezometers). In any case, the impact of mass wasting in the construction and evolution of the Mozambique margin is relevant. Mass wasting is likely linked to fluid escape, has interaction with the action of strong bottom currents and is a recurrent process affecting relevant volumes of the post Eocene sedimentation regionally (over > 100 km along the margin). The studied landslides could be analogous of more ancient deeply buried landslides in post Eocene series of the margin potentially acting as fluid barriers/seals.

PLEISTOCENE-AGE HYDROCARBON-IMPRINTED CARBONATES IN THE NORTHERN APENNINES (ITALY)

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Hydrocarbon-imprinted deep-water carbonates are widely distributed in the Miocene of Italy, known informally as “Calcare a Lucina”. Post-Miocene examples of such type of carbonates are far less common. One such situation of Pleistocene age occurs in the Northern Apennines badlands at Quattro Castella (Reggio Emilia Province, Italy). This authigenic carbonate body, capped by a shell bed, is located on the northern flank of the Quattro Castella anticline, at the boundary between muddy offshore (Argille Azzurre Formation) and coastal (Sabbie Gialle Formation) deposits. Stable isotope composition shows $\delta^{13}C$ values ranging between -52.56 to -53.00‰ VPDB and $\delta^{18}O$ value of ca 5.50‰ VPDB. Stable carbon isotope data and associated chemosymbiotic macrofauna (lucinid bivalves in life position) of the Quattro Castella carbonates provide robust evidence of hydrocarbon seepage at the time. Three km to the west of the Quattro Castella outcrop, seep carbonates are documented in the shelfal Pleistocene deposits of the Torrente Enza as lastroid bodies and pipes overlaid by a biodetrital bed enriched in rhodolites and pectinid shells. We tentatively correlate this shell bed with its equivalent at Quattro Castella, thus hypothesizing that that hydrocarbon seepage occurred regionally, in a time interval comprised between 1.8 and 1.4 Ma. These data provide further support to a model envisaging that hydrocarbon seepage and associated plumbing system took place during a phase of tectonic uplift of the Quattro Castella anticline.

MICROBIAL SEDIMENTS FROM THE THROMBOLITES OF CUATRO CIENEGAS, NORTHEASTERN MEXICO

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As a vast reservoir of microbial diversity and other endemic macrospecies, Cuatro Cienegas also harbors microbialites where multiple mineral-microbial interactions may be imprinted in their microtexture. Thrombolites from Rio Mezquites in Cuatro Ciénegas, Coahuila, northestern Mexico are prominent geomorphological features formed near the sediment-water interface. They occur as small dome-shaped thrombolites, large donut-like mounds or irregular masses of microbial carbonates with a high synoptic relief. Their surface may be sputtered with clumps of benthic microbial mats of cyanobacteria and diatoms. The microscopic analysis revealed the occurrence of pennate diatoms of the genera *Amphora, Diatomella, Epithermia* and *Tabellaria*. These specimens may occur in colonies as solitary frustules or in colonies as is the case for *Tabellaria* sp. Diatoms, in association with connecting organic fibers and other carbonate sedimentary precipitates inside the highly porous infrastructure of these travertines, are major biosediments. At the same time, other microbial structures left by endolithic cyanobacteria are evident inside these modern sedimentary structures, and similar to many other microbialites thorough the fossil record.

SUBSIDENCE HISTORY AND GEODYNAMIC EVOLUTION FROM A BACKSTRIPPING ANALYSIS OF SELECTED WELLS IN THE GULF OF GABES BASIN (OFFSHORE TUNISIA)

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The Mesozoic-Cenozoic Gulf of Gabes Basin is part of the Pellagian province, represented by the offshore shelf area of east-central Tunisia and northern Libya. The succession develops on a relatively stable platform affected by major NW-SE oriented faults, responsible for rapid thickness changes. To reconstruct the subsidence patterns and the geodynamic evolution of the Tunisian offshore basin nineteen hydrocarbon wells data have been used to produce total and tectonic subsidence curves.

The obtained curves have been compared, in order to i) idetify changes in subsidence across the basin and through time, ii) identify possible episodes of syndepositional tectonics iii) identify the position of active faults, as well as their period of activity. According to changes in the subsidence trends in different groups of curves, five different time intervals have been identified.

To highlight the changes among wells, the average subsidence rates for each well in each considered time interval has been calculated (in meters for millions of years). The averaged subsidence rate for each considered time interval has been plotted on maps defined for a single time-interval. This elaboration permitted to group, for each of the five considered time interval, wells with similar subsidence, identifying portion of the basin with similar subsidence patterns. In detail, this elaboration permitted to bring out, for each time interval, parts of the basin characterized by reduced subsidence, different from areas with higher subsidence. The construction of different maps for the different time intervals also permitted to reconstruct changes in the subsidence behavior across time, recording changes in the distribution of subsidence in the basin in different times.

TOWARD AN UNDERSTANDING OF THE GAS-HAPLOOPS LINKS THROUGH THE INVESTIGATION OF THREE DIFFERENT HYDRO SEDIMENTARY ENVIRONMENTS, OFFSHORE THE COAST OF SOUTH BRITTANY AND LOIRE ATLANTIC (WESTERN FRANCE): THE ROLE OF POCKMARKS

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Haploops species are amphipods crustaceans who build dense tube mats in muddy environments. Those engineers species play a bio-sedimentological key role in ecosystems processes. Indeed, their constructions modify the local seafloor characteristics (densification and uplift), catching the sediments particles and the currents flows. Their empty tube rooted in the first centimeters of the sea floor sediments allows water circulation and then influences the early digenesis processes.

Haploops occurrence in specific environments remains unclear but a link with the biogenic methane observed in the sub-bottom layers has been highlighted. To underline this link, three ecosystems have been investigated in south of Brittany and Loire Atlantic: (1) the Bay of Concarneau, a calm area without any continental supplies (no important rivers) and protected from large swell waves, (2) the offshore of the coast of Le Croisic (Loire Atlantic), a more energetic environment with high sedimentary supplies from the Loire river, poorly protected by the Plateau du Four at the West and (3) the middle of the Loire estuary, a highly disturbed system with important sediment supplies, mainly constituted of clay, from the Loire itself and from the navigation channel dredging. This last area is submitted to tidal and swell influences and is affected by an anthropogenic activity: large commercials ships anchor in this waiting zone of the Port of St Nazaire).

In those three areas, the same pattern (coincidence) of *Haploops* and gas can be observed. The chirp sub-bottom profiles show that under the *Haploops* fields, gas is stored into the sediment column and in each area, pockmarks occur within these ecosystems. Pockmarks are crater-like figures found in soft, fine grained sediments and formed where seabed's fluids escape. Those pockmarks repartition perfectly matches with the presence of *Haploops* in the three studied environments. Our hypothesis is that pockmarks are the link between the sub-bottom gas and the *Haploops*. As *Haploops* do not have the necessary bacteria to consume methane, indirect explanation should be proposed.

The pockmarks bring methane to the sediment interface and thus either (i) directly expulse some chemical elements (present in the deeper paleovalleys which are necessary for *Haploops* development or (ii) the methane is necessary for chemical reactions at seafloor surface, which may be used to locally increase the primary production of phytoplankton. Both of these hypotheses are currently tested and geochemical analyses should help to better understand the early diagenesis processes occurring in these particular fields of *Haploops*.

USING END-MEMBER MODELING ANALYSIS TO REVEAL SEDIMENT PROVENANCE AND TRANSPORT PROCESSES OF THE HEUKSAN MUD BELT ON TIDE-DOMINATED SHELF, SOUTHWESTERN KOREA

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About 50 m thick of the Heuksan mud belt (HMB) is a set of prograding clinoforms composed entirely of the Holocene mud off the southwest of Korea. Due to its large volumetric muds estimated from the seismic profiles, its source and depositional processes have been controversial over the last two decades. Previous works have shown that there are two different origins for muds, i.e., the Korean only and combined Korean and Chinese, based on the estimation of sediment budget and accumulation rates. Nonetheless, the provenance of muddy sediments remains obscure. In this context, we applied the end-member modeling analysis (EMMA) to determine the provenance of the HMB sediments and depositional processes with high-resolution grain size data of 74 surface sediments. Together, sedimentary facies analysis of the boxcores carried out to serve the interpretation of sediment transport processes. End-member modelling analysis shows that 74 surface sediment samples are described as mixtures of four end-members: 1) unimodal fine sand-sized sediments (EM1), 2) bimodal coarse siltsized sediments (EM2), 3) bimodal fine silt-sized sediments (EM3), and 4) coarse sand-sized sediments (EM4). Two end-members, EM1 and Em^2 sediments are mainly found in the inner shelf, and their distribution decreases from proximal to distal, suggesting their source from Korean rivers. EM1-and EM2-dominated sediments are interpreted to be storm deposits and tidal rhythmites, respectively, being transported by tidal currents and sometimes intensively reworked by storm events. On the mid shelf, where tidal rhythmites are found, the end-member scores show a mixture of EM2 and EM3, implying that EM2 and EM3 are good proxies for tidal influence. The distribution of EM2 decreases gradually proximal-to-distal, whereas the finest EM3 increases toward the distal region. EM2 and EM3 may thus be interpreted to be derived from Korean rivers. Finest EM3-dominant sediments with fine tails (i.e. clay fraction enriched) of grain-size distribution are found on the outer shelf, especially restricted the southernmost distal region of the HMB. Although Em^3 is interpreted here as distal sediments derived from Koran rivers, previous geochemical and clay mineral studies suggest that the sediments can partly be supplied from Chinese rivers, being transported by oceanic currents. The EM1 and EM4 sediments are interpreted to be the sand ridges and transgressive lag deposits, based on their characteristics of sedimentary facies. End-member modeling of grain-size distributions in the HMB allowed quantification of sediment transport processes and its provenance.

STRIKE-SLIP CONTROLLED VERSUS EXTENSIONAL BASINS ON THE WESTERN TERMINATION OF THE NORTH ANATOLIAN FAULT, IN THE AEGEAN SEA, GREECE. PRELIMINARY RESULTS FROM THE WATER CRUISE (JULY-AUGUST 2017)

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The WATER project (Western Aegean Tectonic Evolution and Reactivations) is focused on the study of a tectonically active domain of the northwestern Aegean Sea (Greece): the Oreoi Channel and the North Evia Gulf.

This Oreoi ChannelNorth Evia Gulf domain, including the onshore Sperchios basin, is a key-area at the junction between extensional basins associated with the southward escape of the Aegean crust (e.g. Corinth Rift and Sperchios Rift), the frontal thrusts of the internal Hellenic zones, and the western termination of the active North-Anatolian Fault. New high resolution seismic data (Sparker) in this area were acquired in order to define the location of recent and active faults associated with crustal deformation in this area, and to understand the role of former structures (i.e. paleogene Hellenic Frontal Thrust) in the distribution of recent deformation and associated small sedimentary basins (rift controlled and/or strike-slip controlled).

The aim of this study is notably to constrain recent and seismogenic deformation within that keyarea and to precise the basin geometries and the timing of deformation in order to better understand the role of older crustal heterogeneities.

The WATER cruise was dedicated to the acquisition of high resolution seismic data in order to:

- identify and characterize the recent and active deformations;
- establish a precise structural framework based on detailed faults mapping;
- precise the relative timing of deformation episodes;
- correlate the new marine data to onland structural analysis in order to discuss the role of structural inheritance on recent deformation and on basin development.

IMPACT OF TECTONICS, CLIMATE AND EUSTASY ON STRATIGRAPHIC ARCHITECTURE AND DEPOSITIONAL PROFILE EVOLUTION IN THE GRAUS-TREMP-AINSA BASIN DURING LOWER EOCENE TIMES

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The aim of this contribution is to characterize and hierarchize the controlling factors (tectonics, climate and eustasy) acting at different time and space scales in the Graus-Tremp-Ainsa piggyback basin succession. In order to discriminate the regional vs local controlling factors (i.e. the tectonic impact proper to a piggyback evolution), we focus on the Lower Eocene times, from the Ilerdian (Claret Conglomerates) to the Cuisian (Castissent Formation). This period corresponds to the activity of the Montsec frontal thrust and to the southward transport of the Graus-Tremp-Ainsa piggyback basin.

Starting from facies associations, we reconstruct four successive depositional systems that include all depositional environments, from the alluvial fan to the turbiditic basin. Then we propose a new sequence stratigraphy framework with three levels of hierarchy, allowing us to perform a multi-scale analysis. Our approach, based on a new age model, the computation of accommodation curves and the comparison with eustatic and climate curves, leads to a discrimination of factors acting at a regional scale (i.e. the world / orogeny scale) and at the local scale (i.e. the piggy-back thrust sheet). Local tectonic controls drive abrupt changes of environments and sedimentary processes, local or intense erosion, changes in current directions, rapid thickness variations and differences in accommodation rates between sections.

Concerning the filling of the piggyback basin, we identify 1) an underfilled stage starting with a high flexural subsidence and a frontal anticline blind thrust tectonic control in a carbonate-dominated environment, followed by an increase of siliciclastic sediment supply, 2) an overfilled stage with an increase of the frontal thrust activity evolving from an active emerged anticline blind thrust to a migrating thrust with lateral ramps which decouples the Graus-Tremp uplifted wedge-top basin from the Ainsa subsiding foredeep domain.

We also propose a hierarchy of the controlling factors. At the largest studied resolution, the underfilled and overfilled stages are driven by regional processes, i.e., flexural subsidence and orogeny uplift, which modulate sediment supply and accommodation, and by thrust migration, which increases sediment supply from emerging sedimentary thrust sheets. Eight Long Term Sequences, with an average duration of one million years, are mainly controlled by the alternation between intrabasinal quiescence periods and local tectonics activity resulting from the Montsec thrust migration. The Short Term Sequences, with a period of about 400000 years, are mostly controlled by climate-eustatic variations, which are well expressed during the early stage of piggy-back development, and during periods of relative tectonic quiescence of the underfilled basin stage. Hyperthermal climate events, such as PETM, ELMO (ETM2) and X-event (ETM3), are recognized in the stratigraphic record and might have enhanced on a short time scale the sediment supply by increasing the precipitations and related erosion.

MINERALOGICAL DISTRIBUTIONS AND THEIR CONTROLLING FACTORS IN THE GRAUS-TREMP-AINSA BASIN DURING LOWER EOCENE TIMES

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Lower Eocene sections from the Graus-Tremp-Ainsa Basin (Spain) show well exposed siliciclastic sequences encompassing continental to deep-sea accumulations in a foreland basin. The tectonic framework is dominated by the rise of the Pyrenean axial domain and the development of the Montsec frontal thrust which created and transported the Graus-Tremp-Ainsa Basin as a piggy-back. The climatic evolution from 56 to 48 My shows a general warming trend up to the Early Eocene Climatic Optimum (EECO) with shortterm hyperthermal events (PETM, ELMO, X-EVENT).

The aim of this contribution is to assess the mineralogical distribution in the Graus-Tremp-Ainsa Basin, between the Aren Sandstone (Maastrichtian) and the Castissent Formation (Middle Cuisian), and its controlling factors. In order to get a basinscale view of mineral dispersal, we integrate a large number of sandstone samples into a high resolution sequence stratigraphic framework. An automated mineralogy is computed from whole-rock chemical data and calibrated against direct mineral quantifications (petrography, DRX, Qemscan, microprobe) performed on representative sandstone samples. We also integrated quantification of clay mineralogical association from < 2 µm clay fraction on lutites along the representative Isabena Valley section.

Different parts of the basin show contrasting diagenetic overprints. The Graus-Tremp Basin displays an extensive kaolinisation of the uppermost units driven by meteoric fluid circulations and a good preservation of the initial mineralogy in the lowermost units. The Ainsa Basin shows a severe albitisation of the sandstones, coupled with the illitisation of smectites and the loss of the kaolinite in the lutites, in relation to burial. The primary mineral distributions in sandstones are tentatively reconstructed and ascribed to different types of sediment sources (i.e. plutonic, recycled sedimentary and carbonate). Tectonic forcing induces mineralogical variations in sandstones at the My timescale. These variations point to changes in sediment sources driven by the competing effects of intrabasinal tectonics (local thrust displacements) versus basinscale flexural subsidence linked to the orogen loading. Eustasy drives shorter-term cycles (from 200 to 400 ky), and changes in hydrodynamics, grainsize and mineralogy. Climatic signals are dominated by higher frequency (100 ky) events (PETM, ELMO, X-EVENT) leaving a mineralogical signal recorded only in clay fractions from the Isabena Valley section.

IMPACT OF HINTERLAND EVOLUTION IN MINERALOGY OF CLASTICS SEDIMENTS: PRESENTATION OF A NEW PROJECT FOCUS ON THE MOZAMBIQUE MARGIN DURING MESO-CENOZOIC TIMES

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The early stage of oil exploration in sedimentary basins is based both on large scale tectonostratigraphic approach from previous works and conventional imaging data mostly well-logs and 2D seismic. In particular geologists face to the lack of model to be able to better predict the reservoir presence and quality of undrilled basins. The source-to-Sink studies ("S2S") on modern or recent systems are of particular interest because they aim to understand and quantify the link from the source/hinterland area (drainage area, nature of the bedrock, climate and topography) to the sink/basin (slope gradient, shelf size, eustasy and sedimentary process). The application of this S2S approach on ancient sedimentary systems is challenging because of the lack of constraints of some controlling factors like the climate, the composition of the source material, the location and altitude of paleo-reliefs or the extent of the drainage area. Our aim is to explore if there is a way to anticipate the impact of the tectonic /geodynamic and climatic evolution of a hinterland on clastic accumulations in the basin and their related mineralogical composition in the basin using the same data-set that can be obtained during an early exploration phase.

The Mozambique margin during Meso-and Cenozoic times is a well-documented S2S system. The on-going studies by G. Baby, J-P. Ponte PHD's respectively on the South African Plateau and Mozambique Margin provide through times: 1) in the source area, valuable mapping of weathering paleosurfaces that allow to constraint the drainage areas and volume of eroded sediments and synthesis of thermochronology data and 2) in the basin, regional seismic interpretations, paleogeographic maps, quantification of deposited sediments based on news biostratigraphical data. Knowledge of climate evolution during the Cretaceous is improved by palynologic studies from wells done by TOTAL.

Here, we present a new project which will focus on the lithological and mineralogical records on cuttings from two old exploration wells. In order to recognize the impact of provenance, climate, diagenesis and transport processes on sediments mineralogy, we focus on the signature of the sandstones including petrographical analysis (E. Garzanti; Milan University), heavy mineral quantification (S. Ando; Milan University) and U/Pb datation on zircon. We will also quantify along the two wells the clay mineralogical association of lutites by XRD analysis.

TRACKING HOLOCENE ENVIRONMENTAL CHANGES FROM LACUSTRINE SEDIMENTS WITHIN HYDROELECTRIC DAMS IN NORTHERN PYRENEES

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Since the end of the 19th century many hydroelectric dams were constructed in the French Pyrenees and frequently flooded former natural lakes of glacial origin. These dams are today generally largest and also more accessible than natural mountain lakes. Combining sub-bottom profiling (200, 14 and 4 kHz) together with multiproxy study of well-dated sediment gravity cores in these lakes we can identify the deposits following the construction of dams and track further back in time the impact of environmental changes on lacustrine sedimentation. In this study we will present new results from two contrasted valleys (Ariège valley and Néouvielle Massif) collected within the frame of projects hosted by the OHM-Haut Vicdessos Pyrenees from the labex DRHIIM (lakes Fourcat and Izourt) and by the RGF program of the BRGM focusing on the new geological map of the French Pyrenees (Lake Orédon) and discuss the impact of hydrological changes on "paleo" and "neo" lacustrine environments.

HOW FAR CAN WE TRACK THE IMPACT OF MAJOR SUBDUCTION EARTHQUAKES IN NORTHERN PATAGONIA FROM HOLOCENE MARINE AND LACUSTRINE SEDIMENT RECORDS?

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Over the last decade, a significant scientific focus has been dedicated to track back in time the signatures of major subduction earthquakes in Patagonia (Chile, Argentina) were numerous lakes and fjords can provide detailed sedimentary records. Northern Patagonia has been largely exposed to the well-documented May 1960 event and numerous other historical earthquakes since the last five centuries. Recently, regional studies of lacustrine sediments in southern Chile highlighted that depending on their latitudes, these lakes could be either exposed to late Holocene earthquakes similar to the 1960 Valdivia event and/or to the 2010 Concepcion event. Here, combining a Holocene sedimentary record of earthquake triggered turbidites stacked in Reloncavi fjord (41°S, Chile) and a historical sedimentary record of mass wasting deposits in Lago Frias (41°S, Argentina) we suggest: (i) that up to 19 major subduction earthquakes in the 1960 event sector had an irregular return period over the last 7500 years and (ii) that both types of events (1960 or 2010) triggered significant mass movements along major faults zones in the Andes cordillera at this latitude. Such co-seismic movements along these major faults may in addition explain why only the largest historical subduction earthquakes (i.e. 1960 and 1550 events) have triggered volcanic eruptions.

THE EXPRESSION OF EARLY APTIAN TO LATEST CENOMANIAN OCEANIC ANOXIC EPISODES IN THE SEDIMENTARY RECORD OF THE BRIANÇONNAIS DOMAIN

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The Briançonnais domain is an important paleogeographic unit in the Alps, which represents a structural high within the former Alpine Tethys Ocean. Expressions of the most important Cretaceous oceanic anoxic episodes (OAE1 a-d and OAE 2) are exceptionally well preserved in the Subbriançonnais unit at Roter Sattel (Fribourg Prealps, Switzerland). The main target of this study is to reconstruct oxygen contents and trophic levels in the water column for each OAE. For this an integrated multi-proxy approach ($\delta^{13}C$; total organic carbon, TOC; phosphorus; redox and productivity sensitive trace elements, RSTE, PSTE) was used.

At Roter Sattel, RSTE distributions show three intervals of significant maxima in concentrations associated with the highest TOC values (up to 5.45, 4.8, and 5 wt%) and with the lowest Mn contents, in sediments equivalent to the Selli (OAE1a), Paquier (OAE1b), and Bonarelli Levels (OAE2). Our data indicate the presence of intermittent anoxic to euxinic conditions during these episodes. Mo and U enrichment factors (EFs) in the lower Aptian and lower Albian intervals suggest the characteristics of an unrestricted marine environment. In the Cenomanian-Turonian boundary interval, they point to the participation of a particulate Fe-Mn-oxyhydroxide shuttle within the water column. In the OAE1a interval the elevated total phosphorus (P) content associated with higher C_{org}:P_{tot} ratios and maxima in TOC values suggests that a part of the remobilized P remained trapped in the sediments. In contrast, the lower P values associated with RSTE and C_{org}:P_{tot} enrichments in the OAE1b and OAE2 intervals indicate that a significant part of P was remobilized and escaped to the bottom water. Our results highlight the combined roles of regional and global parameters in the development of anoxia and increase in organic-matter preservation during the OAEs. The differentiated topography of the Briançonnais domain associated with global climate and sea-level change and its influence on weathering in general and more specifically on the mobilization of sediments on the adjacent ridge modulated nutrient availability in different proportions during the different "mid"-Cretaceous OAEs.

REGOLITH DELIVERY TO THE SEDIMENT ROUTING SYSTEM

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Production and remobilization of regolith are key processes controlling the availability of clastic sediments and solutes for river systems. Shields of the tropical belts, on which thick lateritic regolith mantles were repeatedly produced by weathering and remobilized by erosion during the Cenozoic, represent a large portion of the non-orogenic continental surface and contributed significant amounts of clastic sediments to the world's ocean. In this contribution, we simulate the nature and magnitude of regolith fluxes to the main river systems of sub Saharan West Africa since the early Cenozoic. Our approach combines (1) estimates of volumetric denudation from subtraction of successive paleotopographies constructed from dated paleolandscape remnants and (2) a range of mineralogical and granulometric properties for regolith profiles developed on type-bedrock lithology exposed to erosion in each drainage basin. An important result is that grain size distribution and mineralogy of regolith fluxes remained nearly constant for three main Cenozoic time intervals (45-24, 24-11, 11-0 Ma) for a given drainage basin. No major variations may be detected either amongst the drainage basins whatever the regolith model and despite spatially contrasted bedrock lithologies. Those results suggest that weathering tends to homogenize the regolith whatever the original bedrock it originates from and that the mineralogical and granulometric structure of regolith fluxes to the sediment routing system may be adequately simulated by a single generic regolith. But grain attrition and modification of clay minerals and oxy-hydroxides take place along the sediment routing system, resulting in a distortion of the original signal provided by the eroded regolith.

AN ANTHROPOCENE RECORD OF SEDIMENT QUALITY IN QUEBEC CITY (QC, CANADA)

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The urbanization of Quebec City (QC, Canada) has gone along with several modifications of the Saint-Charles River catchment, including the impoundment of the river in the early 1970s (Joseph-Samson dam) and the creation of vegetation patches over former industrial lands. A sustainable management of this aquatic ecosystem today requires an environmental assessment of sediments trapped within the reservoir in order to avoid the spread of potentially polluted sediments downstream in the Gulf of Saint-Lawrence in the framework of dam management operations (opening versus closing of the valves).

To do so, a set of sediment samples (surface samples and short-cores) has been collected along a longitudinal transect in the channel of the river to document spatial trends of polymetallic and organic (C10C50, HAPs and PCBs) contaminants. Sedimentological and geochemical analyses include CT-scan, XRF core scanner (ITRAX), grain-size measurements and TOC analyses together with ICPAES and GC-MS for trace metals and organic compounds. Sediment quality has been assessed using Enrichment Factors (EF), Geoaccumulation Index (Igeo) as well as regional (Quebec) and national (Canada, USA) sediment quality guidelines for freshwater ecosystems. First results show a widespread contamination of heavy metals with values above Threshold Effect Level (TEL) for As, Cd, Cu, Ni and Hg and above Probable Effect Level (PEL) for Ag, Pb and Zn. Ongoing investigations using EF and Igeo will help in attributing these contaminations to the urban development and/or to a natural geochemical background. The spatial distribution of metals follows an upstream-downstream gradient likely related to the sediment properties (TOC content, grain-size distribution), the urban density and the location of former industrial lands. Similar trends can be drawn for HAPs, including the priority substances listed by the US Environmental Protection Agency, with values repeatedly above PEL and TEL. Although the use of diagnostic ratios shows a pyrogen origin with a multiple-source combustion. Finally, PCBs have not been detected in this set of samples likely as a result of their prohibition in Canada since 1985, the limited time window covered by the cores and the hydrologic dynamic within the channel that may have flushed former contaminated sediments.

The historical trends of pollutions have in addition been deciphered by analyzing a 7-m long-core collected on a sedimentary levee located upstream the dam. Multi-proxy analyses attest of a succession of flood layers and fine-grained sediments associated to the annual hydrologic cycle of the river. The radiocarbon-based chronology confirms this record covers the period 19722017 with a sedimentation rate exceeding 15 $cm.a^{-1}$. On the basis of XRF results, the period 19721990 has been identified as critical concerning metallic contamination. Ongoing analyses within this sequence will aim at refining the age-depth model to (1) reconstruct the historical distribution of polymetallic and organic pollutions and (2) connect them to domestic uses and industrial point sources of pollution once largely represented along the river shores.

PROVENANCE OF MID-HOLOCENE SEDIMENTS IN THE GREAT RANN OF KACHCHH, INDIA: IMPLICATIONS FOR FLUVIAL SCENARIO OF HARAPPAN CIVILISATION

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One of the earliest and largest urban civilisations flourished at the NW plains of Indian subcontinent along the river Indus and the arid landscapes the Thar Desert. Yet, the sudden demise (3.9 kyrs BP) of the Bronze Age Harappan civilisation, within a few centuries after its zenith (4.6 kyrs BP), remains one of the most debated topics in the history of ancient India. For decades, scholars remained baffled at the larger density of Harappan settlements along the present day ephemeral Ghaggar-Hakra river channel in contrast to that along perennial Indus. Controversy exists on the question of the nature/origin of the Ghaggar during the Harrappan period; i.e., glacial (perennial) versus monsoon-fed (ephemeral). In this context, the Great Rann of Kachchh becomes an important piece of the puzzle as it is the purported confluence of the lost river and the Arabian Sea. In this study we have investigated sediments deposited in the Great Rann since 5.5 kyrs BP in an attempt to decipher their provenance. Using trace element geochemistry and Sr-Nd isotopic ratios as tracers we have quantified sediment contributions from plausible sources and inferred their depositional pathways. Although the $^{87}Sr/^{86}Sr$ and εNd of these sediments, varying from 0.71459 to 0.73066 and from -14.3 to -11.0, respectively, overlap with those of the Indus delta sediments (dominated by material from juvenile rocks of the Indo-Tsangpo suture zone), more than 50 % of the $^{87}Sr/^{86}Sr$ data show much higher values (> 0.728)suggesting significant contribution from continental crustal sources. Many other geochemical parameters (e.g., overlapping trace element patterns with sediments from rivers of Punjab; $Th/Y \geq 0.9$; $Pb/Cr \geq 0.3$ etc.) also support such an inference. Thus our data indicate that beside Indus; other sources have contributed significant amounts of sediments (~20-30%) to the Great Rann since the Mid-Holocene until very recently (~1.4 kyrs BP), which in turn advocates for a continuous Ghaggar-Hakra-Nara drainage system during and after the Harappan Period.

GEOCHEMICAL EVIDENCE FOR A HOLOCENE SARASWATI RIVER AND ITS ROLE IN THE EVOLUTION OF THE HARAPPAN CIVILISATION

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For more than a century, several scholars have hypothesised about the existence of a Holocene glacier-fed paleo-river (the lost Saraswati) which used to flow along the present day ephemeral Ghaggar–Hakra river of north-western Indian sub-continent. The sudden and mysterious ending of the Bronze Age Harappan civilisation (5300-3300 yrs BP) within few centuries of its zenith has often been correlated with the decline of this paleo-river. But there are a lot of debates regarding the nature of the river during Holocene and its role on the evolution of the Harappan Civilisation. During the course of present work, sub-surface fluvial sands have been sampled from the Ghaggar alluvium along a 120 km trail and their trace element and Sr-Nd isotopic characteristics have been studied to constrain the sediment provenance. These coarse, micaceous, grey, sand horizons are visibly distinguishable from the overlying floodplain deposits of brown silty-mud and occur at a depth of 7-12 m. The depositional ages of these grey sands were determined using radiocarbon (of molluscs) and OSL dating (of quartz) methods. While previous works suggest that the river was active during the Pleistocene, our new age constrain suggest that the paleo-channel was active until ~5000 yrs BP. However, there is absence of grey sand deposits during the last glacial maxima. Therefore, the Holocene deposits probably represent a renewed phase of the river. The trace element patterns of these sediments overlap with the modern fluvial sediments of the rivers of Punjab. The Ar-Ar cooling ages of the detrital Muscovites present in the grey sands varies from 20.1 to 18.6 Ma which coincides with the mica ages of Higher Himalayan leucogranites (~20 Ma) and suggest a provenance in the glaciated higher Himalaya. The $^{87}Sr/^{86}Sr$ (0.759 to 0.770) and εNd (-16.9 to -18.9) compositions of the sediments are similar to the sediment carried by higher Himalayan rivers and are very different from the Siwalik derived Ghaggar sediments ($^{87}Sr/^{86}Sr$: 0.733 to 0.747 and εNd: -14.4 to -15.1). Moreover, the $^{87}Sr/^{86}Sr$ ratios of the in-situ mollusc shells from these sand bodies are 0.7187±0.0003 and resemble that of the water of the Sutlej (0.7166 – 0.7218). We therefore infer that some distributaries of the Sutlej were flowing into the paleo-Ghaggar during the mid-Holocene (≥5 ka) as the Ghaggar itself has no higher Himalayan source. This on the other hand indicates that during the beginning of the early-Harappan Hakra culture (~9000 yrs BP) the Ghaggar river was glacier-fed perennial in nature. During the beginning of the mature Harappan period the river gradually became ephemeral. Although, the river disorganised much before the decline of the civilisation, it played a major role in the development of the earliest settlements along its banks.

PHYSICO-CHEMICAL CHARACTERISTICS OF A KIMMERIDGIAN BLACK SHALE: JHURAN FORMATION, WESTERN INDIA

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Compared to their counterparts in early Jurassic and Cretaceous, black shales are poorly represented in late Jurassic. In this study we present physico-chemical characteristics of black shales in the Kimmeridgian Jhuran Formation. These shales were deposited in a peri-cratonic rift basin located at the western continental margin of India. The overall prograding, shelf-originated, three-tiered Jhuran Formation comprises extensive black shale, particularly at the basal part of each Member. The 74 m-thick Lower Member of the Jhuran Formation consists of organic-rich shale, siltstones and sandstones, representing a TST and HST, separated by a maximum flooding zone. Black shales occur at the bottom units of both Middle Member and the Upper Member, with average thicknesses of 155 m and 82 m respectively. Unlike the Lower Member, the upper two Members comprises only of HSTs, separated by granular lags. Thickness of intercalating sandstone/siltstone beds within the black shale increases from the Lower Member to the Upper Member. The sandstone beds bear abundant evidences of wave reworking, including wave ripples, hummocky cross-stratification, and bimodal-bipolar orientation of tool marks. Total organic carbon content of the shale reaches its maxima (~4.9%) close to the maximum flooding zone (MFZ) in the Lower Member and decreases gradually upward. The average diameter of pyrite framboid is < 5 µm near the maximum flooding zone, while it ranges from 6 µm to 15 µm elsewhere in the sedimentary sequence. Enrichment factors for redox sensitive trace elements like vanadium, nickel, uranium etc. increase by two to four times at the vicinity of the MFZ in the Lower Member, while the same factor records a two-fold rise at the bottom of the Middle Member. V/ (V+Ni) versus Th/U cross-plot show anoxic conditions of deposition for these black shales. Good correlation of Cr, Sc, Co and Th with aluminium indicates derivation of these trace elements from detrital source. Therefore, trace element ratios like V/Cr vs Th/U, V/Sc vs Th/U, V/(V+Ni) vs V/Cr, V/Sc vs V/Cr, Ni/Co vs V/ Cr and V/(V+Ni) vs V/Cr fail to provide the correct redox interpretations because of the input of Cr, Co, Sc and Th from detrital sources. Shales of Lower Member and Middle Member exhibit positive Ce anomalies ranging from 0.82 to 0.98 and 0.85 to 1.00 respectively. Integration of results of pyrite framboid analysis, trace element enrichment factors, selected trace element ratios, Ce anomalies and paucity of storm siltstone beds suggest dysoxic to anoxic depositional conditions for black shale close to the maximum flooding zone. Black shales in the rest of the sequence formed mostly in dysoxic condition. Organic debris dumped in large volumes within the shelf environment increased biological oxygen demand, causing an oxygen minimum zone near the seafloor. Lack of wave agitation below the storm wave base facilitated organic enrichment in deeper shelf, while sediments remained organic-poor within the shallower shelf.

DECADAL AND CENTENNIAL EVOLUTIONS OF BEACHES IN CONTRASTED COASTAL ENVIRONMENTS

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Coastal erosion is widespread in the world and is expected to increase due to sea level rise and, locally, changes in wave climate. Managing coastal erosion requires long-term monitoring in order to quantify geomorphological changes, identify forcing parameters and predict future evolutions.

We focus on the Charente-Maritime shoreline (Southwest France) were some of the fastest coastal retreats have been reported at the scale of Europe. Such shoreline retreat is critical since this coastal area is one of the most attractive and is characterized by the largest surface areas below the highest astronomical tides at the scale France. The coastline is irregular and characterized by large embayments, corresponding to drown incised-valley segments, which induces very contrasted wave conditions and sediment budget from one beach to another.

All along the 460 km-long shoreline of Charente-Maritime, 27 beaches, representative of the coast diversity, have been studied at two time scales: 13 cross shore topographic profiles (from 1999 to 2016), 2 aerial photos (2000 and 2010) and 2 satellite images (2014 and 2016) show the annual to decadal morphological evolutions; 2 historical maps (1824 and 1872) and 2 old aerial photographs (1945 and 1973) show the decadal to secular morphological evolutions.

Despite several uncertainties related to data accuracy and shoreline interpretation, the comparison between coastline evolutions measured from both topographic profiles and aerial photos or satellite images show strong similarities, providing a validation of the methodology.

This study shows large variations in maximum cross-shore coastal evolutions from accretion reaching +25 m/yr to erosion reaching137 m/yr, whereas some beaches remained stable. Three controlling factors may explain such spatial variations: wave exposure; bedrock control and beach location relative to inlets. Fastest erosion rates, with mean erosion rate higher than 4 m/yr, are observed on beaches close to tidal inlets. Beaches characterized by bedrock outcrops in the lower foreshore always displayed mean erosion rates lower than 2 m/yr. Most of the beaches located in sheltered environments (70% of wave height attenuation with respect to offshore conditions) displayed sediment accretion or remained stable.

Important temporal variations in morphological evolutions are also evidenced. Increasing shoreline erosion during the 20th century has only been observed on 4 beaches among 27, although wave height has increased during this period. Moreover, maximum erosion rates are not correlated with years during which extreme storms occurred: only 7 beaches among 27 showed maximum annual erosion rates in 2013-2014 (year of the most energetic wave climate of the last 70 years); and 6 beaches showed maximum annual erosion rates in 1999-2000 (year of cat. 3 Martin Storm with strongest wind measured over the 20th century). Largest temporal variations in morphological evolutions, characterized by alternation of fast erosion and accretion periods, are observed on beaches located near tidal inlets. Such changes are correlated with the main inlet channel orientation since updrift beach erosion occurred when the inlet channel was oriented downdrift and updrift beach accretion occurred when inlet channel was oriented updrift.

SHORT-TERM HIGH RESOLUTION DYNAMICS OF A TIDAL INLET: THE MAUMUSSON INLET, SW FRANCE

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Tidal inlets are among the most dynamic coastal environments, due to the combination of waves, strong tidal currents and shallow banks and channels. In a context of climate change, there is a need to improve our knowledge about the physical processes involved in tidal inlet morphodynamics, and to identify the contribution of storm waves and sea level changes (including local storm surges and global sea level rise) relative to more widely studied hydrodynamic parameters (waves and tides). Accurate geomorphologic and hydrodynamic measurements together with morphodynamic modelling are needed to meet this demand.

We focus on a tidal inlet located on the central-west coast of France (Maumusson Inlet) where we already collected and published a large amount of data about its long-term morphodynamics. As the shorelines adjacent to the inlet are experiencing large erosion rates (locally more than 30 m/yr) there is an urgent need to understand which processes are responsible in order to be able to predict future evolution.

We conducted bathymetric (interferometric sonar, R/V Haliotis) and topographic (photogrammetry from an Unmanned Aerial Vehicle) surveys coupled with hydrodynamic measurements (ADCP, turbidimeter and 3 pressure sensors deployed over the tidal deltas) in May 2017. This data provides local insights about the hydro-sedimentary dynamics (current vertical profiles, water slopes, sediment fluxes and wave propagation) and will be further used to calibrate 3D morphodynamic modelling using SCHISM. This modelling system fully couples a 3D baroclinic circulation model, the spectral wave model WWMII and the 3D sediment transport and bed update model SED3D.

The DEM obtained after merging bathymetric and topographic data allows distinguishing bedforms in detail. Subaqueous dunes were identified, based on their wavelength and height. Bathymetric data recorded in the main inlet channel and on the flood delta show the development of medium subaqueous dunes (wavelength < 10 m) superimposed on very large subaqueous dunes (wavelength > 100 m). Repetitive bathymetric surveys show that subaqueous dune migration reached 2 m/day. Topographic data recorded on the ebb delta show the development of medium and subaqueous dunes (wavelengths from 10 to 100 m) on both sides of the flood channels; and large subaqueous dunes superimposed on large and very large rhomboid subaqueous dunes, indicative of high velocity and very shallow water on the landward part the ebb delta.

Lee face orientations of subaqueous dunes were used as indicators of sand transport and compared with residual sand transport computed from preliminary 2DH modelling. Sand transport patterns deduced from bathymetric data and modelling show strong similarities in the main channel and around the flood delta. On the opposite, differences are observed at the top of the ebb delta, which are explained by the inversion of dune polarity within a tidal cycle.

Bathymetric differences, between November 2016 and May 2017, shows sediment infilling of the main channel and accretion of the ebb delta occurring during winter. Those morphological evolutions are interpreted as resulting from a seasonal cycle, where more energetic winter waves decrease the ebb-dominance of the inlet main channel and locally promote flood-dominance.

INTEGRATION OF MARINE ORGANIC MATTER DEPOSITION IN A STRATIGRAPHIC FORWARD NUMERICAL MODEL (DIONISOSFLOW): APPLICATION ON THE DUVERNAY FORMATION (CANADA)

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The distribution and quality of organic matter in source rocks are key elements when assessing petroleum systems. It is also of primary importance to picture heterogeneities within source rocks for the particular interest of unconventional prospects.

Stratigraphic models help to improve the prediction of sedimentary architectures and distribution. Their use has shown good results for the assessment of oil and gas resources. Among the stratigraphic software available, DionisosFlow provides the opportunity to simulate clastic, carbonate and mixed systems in complex tectonic settings, from reservoir to basin scales. Recent developments also allow the simulation of the marine organic matter production and degradation processes. Physically-based approaches consist in linking the organic production to different parameters in order to re-construct the main productivity trends reflecting the nutrients availability. Degradation stages occur in the water column and during the early burial. The degradation amplitude depends on the depositional environment characterized from the sedimentation rate, the bathymetry and the redox conditions. The coupling with DionisosFlow simulates the transport of the marine organic matter allowing the model to reproduce realistic depot-center distributions. The final aim of this work is to challenge conceptual geological source-rock depositional models but also to bring initial TOC and HI maps for petroleum system basin modeling.

An application of the marine organic matter depositional model has been performed on Duvernay formation (Western Canadian Sedimentary Basin). Comparison of the simulation results and the basin-scale geological characteristics is presented. Although several improvements still need to be done (e.g. the influence of bottom circulation on sediment and nutrients distribution), our simulation results demonstrate the capacity of the model to reproduce both realistic geological scenario source-rock signatures.

INTEGRATION OF TERRESTRIAL ORGANIC MATTER PRODUCTION AND PRESERVATION IN A STRATIGRAPHIC FORWARD NUMERICAL MODEL: APPLICATION ON THE MANNVILLE GROUP (CANADA)

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Predicting the occurrence and the organic attributes of source rocks is fundamental for exploration and for optimal shale gas or shale oil production. Among the numerical tools use to better characterized a petroleum basin, the stratigraphic model DionisosFlow provides the opportunity to improve the prediction of sedimentary architectures and distribution, for both carbonate, clastic or mixed system. Moreover, recent developments investigate the production and degradation processes of marine organic matter to better predict its distribution and quality, from reservoir to basin scale.

The latest developments allow the simulation of in-situ accumulation of terrestrial organic matter. The distribution of the accumulation zones is mainly controlled by the continental hydrological conditions. The description of the hydrological conditions in DionisosFlow is obtained by simulating both the surface flow and the groundwater flow. Depending on the geological processes (thermal and/or tectonic subsidences and sea level variations, involving erosive events) the organic matter will either remain in place or be transported into the marine realm.

First synthetic case-studies have illustrated different regimes of terrestrial organic matter accumulation depending on the accommodation space. The validation of the terrestrial organic matter accumulation model has been completed by comparing the simulation results to the geological characterization of the Mannville Group (Alberta, Canada). Results show that DionisosFlow can accurately simulate the coal distribution into the main system tracts of the 3rd order stratigraphic sequence. These new developments embedded in DionisosFlow provide a tool to investigate the initial source-rock signature (bulk TOC and HI) resulting from the mixing between different organofacies.

TWO EXAMPLES OF ORE GEOLOGY IN SEDIMENTARY REALM FROM MOROCCO: THE MANGANESE AND PHOSPHORITES DEPOSITS

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During the meso-cenozoic times in Morocco, ore geology in sedimentary realm will concern two types of deposits:

Manganese:

The economically important high-grade manganese ores of the Imini district are exceptional because of their unusually high Mn/Fe ratios and exceptional enrichment in Ba and Pb. There is ample evidence that the three strata-bound manganese ore bodies of the Imini district formed in a laterally extensive karst cave system, associated with internal sediment, and developed in a shallow marine dolostone succession of Cretaceous age. The manganese ores occur in dolostone breccias and ferruginous clays that represent the earliest phase of internal sediment in the cave system. Later phases of cave infilling are ferruginous without manganese enrichment. Ore formation, karstification, and meteoric dolomitization are all related to an extended period of exposure and terrestrial weathering, prior to the deposition of terrestrial red beds and evaporites of Upper Cretaceous age that overlie the ore-bearing dolostone succession above an erosional unconformity. The manganese ores formed when warm, acidic $Mn^{2\pm}$ bearing meteoric water migrated from the elevated regions of the Anti-Atlas region into the exposed carbonate succession. Alkali feldspar-rich igneous basement rocks were the source for Mn, Pb, and Ba. Metals were deposited in a zone of mixing between metal-bearing, reducing meteoric water and oxygenated ground water resident in the cave system.

Phosphorites:

The element phosphorus is essential to all terms of life on earth. The element plays a fundamental role in many metabolic processes and as a major constituent of skeletal material. Phosphorus occurs in over 200 mineral species. The most common forms are minerals of the apatite family, a calcium phosphate with various substitutions.

The general occurrence of phosphate rocks is commonly bound to lithofacies associations which are rich in organic matter. But in smaller scale, the phosphate mineral contents in the rock are usually associated with a decrease in the organic matter compound. The term phosphogenesis summarizes all processes of apatite precipitation/mineralization explained by the oceanographic “upwelling models”.

During Late Cretaceous-Paleogene time in Morocco, the phosphorite depositional paleoenvironment, is predominantly developed in epicontinental sea along a ramp setting. Sea-level induced environmental shifts to more agitated water conditions in a tectonically stable basin, this ramp setting attributes sediment remobilization to sea-level stages, respectively to transgressive and highstand system tracts.

STRONG OCEANIC AND CLIMATIC FLUCTUATION CHARACTERIZED BY CARBON ISOTOPE AND WEATHERING INDEXES OF THE ORDOVICIAN-SILURIAN TRANSITION IN THE YANGTZE AREA, SOUTH CHINA

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Persuasive evidence suggests that the Ordovician-Silurian transition was a critical interval in Earth's history especially marked by Late Ordovician glaciation and mass extinction. In the absence of direct glacial deposits on the Yangtze area of south China, evidence of climate changes during Ordovician-Silurian transition in Yangtze area remains scarce relatively. Hence, carbon isotopic compositions of organic matter ($^{13}C_{org}$) and a series of chemical weathering indexes are analyzed from Tianjiawan section and SD-1 drill core (both located in Yangtze area of south China). We present $\delta^{13}C$ of marine sediments across Ordovician-Silurian boundary as a proxy of CO_2 concentration in ocean surface water [CO_2 (aq)], and chemical weathering indexes including CIA, CIW, PIA, CIX, MIA-O, LCWP, CDF and TNa of marine sediments across Ordovician-Silurian boundary as a proxy of changes in intensity of chemical weathering, in order to explore the oceanic and climatic changes. The $\delta^{13}C$ values of Tianjiawan section vary from –31.2‰ to –28.5‰ and show a positive excursion within Hirnantian interval, implying a low CO_2 concentration in ocean surface water and low photosynthetic rate. The chemical weathering indexes of Tianjiawan section and SD-1 drill core indicate a warm and humid climate continuously exist in late Kaitian and early Rhuddanian, but cold and dry climate accompanied by short-term pulses of warming climate during Hirnantian. This study demonstrates not only that large climatic fluctuations and oceanic turnover exist during the Ordovician-Silurian transition but also climatic fluctuations, together with multiple oceanic changes, play an important role in Ordovician-Silurian biotic mass extinction.

FLUME TANK STUDY OF THE FORMATION PROCESS AND SEDIMENTARY CHARACTERISTICS OF SHALLOW-WATER DELTA

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This paper investigates the influence of water level oscillation and sediment supply volume on shallow-water delta development and facies interaction characteristics by means of a flume experiment. The experiment revealed that during the high water level period, flood broke the former channels and a large amount of sediments were evenly transported and unloaded on the surface of lobes. Erosion appeared when the water level began to fall and was dominant at lowstand. Most sediments were concentrated in incised valleys and unloaded at channel mouth to form a new lobe during the falling limb. However, when the water level re-rose, incised channels and lobes were broken to some extent. Sediments homogeneously covered the surface of lobe and few new lobes appeared in this period. The high amplitude and low frequency of water level oscillation were conducive to form high thickness sand body and stable lobe under the same sediment supply. Different sediment supply influences not only the timing of sequences evolution stages and onset of fluvial incision, but also the characteristics of incised valleys and channel style. Low sediment supply delta was strongly influenced by water level change while high sediment supply delta was effected by fluvial process. During relative sea-level fall, low sediment supply lead to early initiation of fluvial incision and development of few, but distinct incised valleys. These incised channels were narrow and deep and localized most sediment to major lobes. In contrast, high sediment supply resulted in numerous, poorly developed incised channel and sediments simultaneously scattered and formed arrays of small lobes. Based on the quantity and proportion of sediments and water, channels on delta can be classified as four types: a) narrow and deep multiple channel, with the ratio of width to depth (W/D) of 1.1-3.5, b) narrow and shallow branch channel with W/D of 5.1-12.9, c) broad and shallow main channel with W/D of 7.3-20.2 and d) broad and deep stable channel with W/D of 2.6-4.6. Most of mouth bar were initially formed and then were broken by the water level oscillation and channel bifurcation. The remaining mouth bars were reserved at the far end of lobe where underwent the low-energy environment.

THE INFLUENCES OF CLIMATE AND WATER-LEVEL CHANGES ON THE EVOLUTION OF SEQUENCE STRATIGRAPHY AND SEDIMENTARY SYSTEM OF THE LOWER CRETACEOUS, IN THE FULA SAG MUGLAD BASIN SUDAN

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Sequence-stratigraphic and sedimentologic theories and methods were employed in the study of sequence stratigraphic features and sedimentary system distributions in the Cretaceous of the Jake oil field in Fula sag Muglad Basin Sudan. Data gathered through core drilling and logging and seismic events were resorted to establish sequence stratigraphic framework, determine the types and distribution of sedimentary facies and understand evolution pattern and controlling factors in Lower Cretaceous. The Cretaceous can be described as 3 second-order sequences and Lower Cretaceous can be divided into 7 three-order sequences. The result shows that sedimentary facies including fan delta submarine fan braided river deltas and rivers deposits were recognized in the Lower Cretaceous. Depositional facies varied vertically from fan delta to submarine fan and then to braided river delta in Abu Gabra Formation, and from braided river to meandering river and then to delta in the Bentiu Formation. The distribution of the sediments is controlled by multifactors in Jake oil field. Vertically, tectonic activity is a main factor which control the facies change in Abu Gabra. Synsedimentary process lead to the thickness of sediments from Cretaceous to Tertiary increased with the average rate of 21.25 m/km basinward. The alternation of paleocurrent direction also influenced the sediment process in Bentiu Formation which altered the paleocurrent form southeastwards to northeastwards. Climate change and coast recession mainly affect the facies distribution. With the change from semiarid to humid climate, the low-Sinuosity braided channels under low base level turn to high-Sinuosity meander channels under high base level environment. The gentle ramp and high temperature result in rapidly recession which altered the delta front to prodelta in Aradeiba Formation. Horizontally sediments supply and local subsidence differences controlled the distribution of sand body.

IDENTIFICATION METHOD AND APPLICATION OF CARBONATE DEPOSITION MICROFACIES USING IMAGE LOGS: A CASE STUDY FROM MAJIAGOU FORMATION OF ORDOS BASIN, NORTH CHINA

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Depositional facies plays an important role in the reservoir quality and gas bearing property, and therefore the reservoir quality of the Majiagou reservoirs is facies controlled and thus potentially predictable providing that the small-scale depositional microfacies of the reservoir rocks are known. However, it's difficult to predict the microfacies in a single well due to the limited core data. The high-resolution borehole image logs (FMI) could provide continuous digital records of reservoir rocks with information about lithology, depositional textures, and sedimentary sequences, and therefore can be used for the detailed interpretation of sedimentary facies.

The objectives of this study are to: (1) summarize the depositional facies of the Majiagou Formation in Ordos basin according to the previous studies; (2) describe the depositional microfacies according to core, outcrop data; (3) understand the conventional logging responses of various depositional facies; (4) summarize the image log characteristics of various depositional facies; (5) predict the depositional facies using a combination of conventional logs and image logs.

A total of 800 m length cores from 45 wells such as Lian 30, Jin 2, Jin 7 are availabe for us, which will provide insights into the depostional microfaces analysis of Majiagou Fomration. Cores are indispensable for the calibration of image logs, and the comprehensive integration of core data with image logs lead to improved sedimentological interpretations of subsurface reservoirs. The available conventional log suites include GR, SP, CAL, AC, CNL, DEN, and Rxo and Rt. Image logs, which are classified as unconventional well logs, are available from 68 wells. The core-to-log depth matching is performed by correlating the GR signature as well as image logs with the core description.

By a combination of outcrop, core sample, well logs and image logs, the sedimentary environment of the Ordovician Formation in the study area is recognized as a platform, and the tidal flat is the dominant subfacies. Additionally the gypsum-bearing dolomite flat, dolomitic flat are the dominant depostional microfacies. Also, there are some other depostional microfacies such grain bank, and mud flat. The logging response characteristics of various depositional microfacies are summarized, and the depositional microfacies is then predicted by using a combination of conventional log suits and image logs. By calibrating the depostional micro-facies with core-measured porosity, permeability as well as the gas test data, it can be concluded that gypsum-bearing dolomite flat, dolomitic flat correspond to the high-quality reservoirs and favorable gas bearing intevals.

The sedimentary environment of the Ordovician dolomite in the study area is restricted platform in which the gypsum-bearing dolomite flat, dolomitic flat and grain bank are favourable for high qualigy reservoir development. The most important reservoir is dolomite reservoir, and the main pore space is intercrystalline pore, dissolved intercrystalline pore, dissolved pore and micro-fracture. By the contrast of image and conventional logging characteristics of the above depostional microfacies, we summarize the relationship between carbonate platform facies and image logs, and predict the depositional microfacies using a combination of conventional and image logs.

CONTROL OF DIAGENETIC FACIES ON TIGHT OIL RESERVOIR PORE STRUCTURE: THE CHANG 7 OIL LAYER IN HESHUI AREA OF ORDOS BASIN, CHINA

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The Chang 7 tight oil reservoir in Heshui area of Ordos basin are characterized by low porosity, low permeability and strong heterogeneity due to the extensive diagenetic modifications they had experienced. Therefore, it is of great importance to investigate the microscopic pore structure and unravel the control of diagenesis and diagenetic facies on reservoir property and pore structure. Petrologic characteristics, physical properties and logging response characteristics of Chang 7 tight oil reservoir were studied by means of core observation, thin section observation, scanning electron microscopy and image log analysis. The diagenetic facies and pore structure were classified by making full use of various laboratory analysis data such as highpressure mercury injection method and nuclear magenetic resonance.

Four types of Diagenetic facies were divided based on diagenesis and diagenetic mineral as well as diagenetic evolution sequence, including dissolution of unstable components facies, clay minerals filling facies, carbonate cementation facies and tightly compaction facies. Pore structure were divided into four types according to the mercury injection tests and nuclear magnetic resonance measurements, including mesopore-fine throat, fine pore-fine throat, micropore-fine throat and micropore-leptothroat. Through the analysis of the relationship between different diagenetic facies and pore structure characteristics, it can be concluded that dissolution of unstable components facies corresponds to the best pore structure type, followed by clay minerals filling facies and carbonate cementation facies. In contrast, the tightly compaction facies corresponds to the poorest reservoir quality and pore structure. The relationship between different diagenetic facies and pore structure characteristics are also testified well with gas test results.

A total of 5 logging curves which are sensitive to diagenetic facies, namely, interval travel time (AC), resistivity, natural gamma, and density and neutron, are selected to establish logging identification criteria of the 4 kinds of diagenetic facies. Then the vertical distribution of diagenetic facies in a single well is figure out. Finally, the distribution of favorable porosity and permeability zones within Chang 7 tight oil reservoir in Heshui area are predicted by using the distribution of favorable diagenetic facies region. The results above could provide geologic bases for further exploration and development of tight oil resources in Ordos basin and have implications for the tight oil reservoirs elsewhere.

SWEET SPOT PREDICTION IN TIGHT OIL RESERVOIRS BASED ON PETROPHYSICAL FACIES

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Generally, petrophysical facies refer to the genetic units of reservoir which has certain petrophysical properties and percolation characteristics. Petrophysical facies is a comprehensive reflection of depositional facies, diagenesis and fractures. The characterization of petrophysical facies is an intuitive expression and systematic summary of its formation mechanisms, features and distribution. The reservoir types and lithology of Chang 7 tight oil reservoir in Heshui area of Ordos basin are complex. It is difficult to evaluate the reservoir effectiveness and fluid properties. Therefore, logging evaluation reservoir is restricted. Classification of petrophysical facies reflects the control effect of lithology, physical properties, pore structure and logging response on reservoir quality. Therefore, petrophysical facies is the dominant factors to control "fourproperty" relationship and logging response characteristics of tight oil reservoir. Petrologic characteristics, physical properties and logging response characteristics of Chang 7 tight oil reservoir were studied by means of core observation, thin section observation and image log analysis. The lithofacies, diagenetic facies and pore structure of Chang 7 tight oil reservoir were classified by making full use of various laboratory analysis data. Five types of lithofacies were recognized, including fine sandstone of sandy debris flow facies, turbidity sandstone facies, fluxoturbidite facies, mudrock of semi-deep water or deep water facies and oil shale facies. Diagenetic facies were divided into four types based on diagenesis and diagenetic mineral as well as diagenetic evolution sequence, including dissolution of unstable components facies, clay minerals filling facies, carbonate cementation facies and tightly compaction facies. Pore structure facies were divided into four types according to the mercury injection tests and nuclear magnetic resonance measurements, including mesopore-fine throat, fine pore-fine throat, micropore-fine throat and micropore-leptothroat. Identification and characterization method of well logging in different lithofacies, diagenetic facies and pore structure facies was established based on correlation from core to curves of conventional logging, image logs and nuclear magnetic resonance log. Then petrophysical facies were divided according to the superposition and combination of lithofacies, diagenetic facies and pore structure facies. Petrophysical facies can be used to predict the "sweet spot" in a single well in the longitudinal direction. Research results can provide theoretical guidance and method supports for logging evaluation of tight oil reservoirs in other blocks of Ordos Basin, as well as promote the progress of petrophysical facies.

SEDIMENT PROCESS AND FLUX DURING SHELF-EDGE CLINOFORM GROWTH SINCE THE LATE CENOZOIC, QIONGDONGNAN BASIN MARGIN, NORTHERN SOUTH CHINA SEA

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The continental shelf clinoforms of Qiongdongnan Basin margin, South China Sea, has grown since 10.5 Ma Late Cenozoic time, which generated more than 4 km-thick shelf prism above the T40 surface. As the hub of the continental shelf, the shelf margin clinoform and trajectory show downflatting and rising patterns where the progradation and aggradation of cross-shelf transits happened. By using the core, well drilling data, and estimation and calculation method based on 2D seismic lines, this study aim to: 1) illustrate the clinoform patterns (including the shelf-edge trajectory and toe of slope trajectory) and the clinothem architectures and shapes through the vertical evolution of the delta regime with at least 5 main boundaries (T40, T30, T27, T20, T0) and 15 basic clinothem units; 2) demonstrate the geometry morphology of the clinoforms and mechanism of the shelf margin accretion with the sediment flux calculation of each clinothem, which includes the estimation of sediment flux and volumes, and to exam the quantitative results and predicted ratio of the sediment flux across the shelf-edge; 3) reconstruct the source-to-Sink system equilibrium from shelf through shelf margin to deepwater slope and basin floor with the discussion of the controls of sand transfer system on the shelf margin clinothem evolution and their interactions; 4) and furthermore, understand the responds of Cenozoic shelf margin sediment processes and flux to global transgressive-regressive events or climate cycles with the considering of factors of tectonic subsidence, accommodations, climate changes, and high frequency sea level changes during ice-house.

NEW EVIDENCES FROM ZIRCON XENOCRYSTS OF DIABASE FOR THE DATING OF THE XIANGSHAN GROUP IN THE ZHONGWEI REGION, WESTERN NORTH CHINA PLATE

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The age of the Xiangshan Group has been controversial since the unit was described in the 1960s. Ascertaining the age of formation of the Xiangshan Group is crucial to elucidate the regional tectonic evolution and the depositional environment of the group. A large number of magmatic and detrital zircons were obtained from diabase veins in the Langzuizi Formation of the upper Xiangshan Group in the Zhongwei area. Using high-precision SHRIMP U–Pb dating technology, we conducted geochronological research on these zircons. The results from the zircon dating demonstrated that the Xiangshan Group probably formed in the Late Ordovician–early Silurian, between 461 ±11 and 433 ±2.4 Ma. Moreover, the Langzuizi Formation diabase veins of the Xiangshan Group probably formed in the late Permian to Middle Triassic and were extensively emplaced between 225 ±1.1 and 257 ± 5.5 Ma, rather than the previously accepted early Palaeozoic age. By comparison and analysis of the age spectra of the basement rocks of central Qilian, northern Qilian, the Alxa block and North China, we determined that the curves in the age spectra of the Xiangshan Group correlate well with those in the detrital zircon age spectra of the northern and central Qilian regions. The Xiangshan Group spectra also reflect the characteristic age values of the Alxa basement. Therefore, it can be inferred that the materials of the Xiangshan Group mainly originated from both Qilian block or some other area, with a small amount from the Alxa block.

CONTINENTAL WEATHERING AS A DRIVER OF LATE CRETACEOUS COOLING: NEW INSIGHTS FROM CLAY MINERALOGY OF CAMPANIAN SEDIMENTS FROM THE SOUTHERN TETHYAN MARGIN TO THE BOREAL REALM

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New clay mineralogical analyses have been performed on Campanian sediments from the Tethyan and Boreal realms along a palaeolatitudinal transect from 45° to 20°N (Danish Basin, North Sea, Paris Basin, Mons Basin, Aquitaine Basin, Umbria-Marche Basin and Tunisian Atlas). Significant terrigenous inputs are evidenced by increasing proportions of detrital clay minerals such as illite, kaolinite and chlorite at various levels in the mid-to upper Campanian, while smectites predominate and represented the background of the Late Cretaceous clay sedimentation. Our new results highlight a distinct latitudinal distribution of clay minerals, with the occurrence of kaolinite in southern sections while this mineral is almost absent in northern areas. This latitudinal distribution points to an at least partial climatic control on clay mineral sedimentation, with a humid zone developed between 20° and 35°N. The association and co-evolution of illite, chlorite and kaolinite in most sections suggests a reworking of these minerals from basement rocks, which we link to the formation of relief around the Tethys due to compression associated with incipient Tethyan closure. Diachroneity in the occurrence of detrital minerals between sections, with detrital input starting earlier during the Santonian in the south than in the north, highlights the northward progression of the deformation related to the anticlockwise rotation of Africa. Increasing continental weathering and erosion, evidenced by our clay mineralogical data through the Campanian, may have resulted in enhanced CO_2 consumption by silicate weathering, thereby contributing to late Cretaceous climatic cooling.

PROVENANCE OF THE UPPER PALEOZOIC TAEAN FORMATION IN THE WESTERN GYEONGGI MASSIF, CENTRAL WESTERN KOREA AND ITS PALEOGEOGRAPHIC IMPLICATIONS

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Mineral and geochemical composition and Sm/Nd isotopic composition of the Upper Paleozoic Taean Formation distributed in the western Korean Peninsula, were analyzed to infer its provenance characteristics and to understand the tectonic environment of the East Asian continental margin during the late Paleozoic. The Taean Formation comprises turbidite facies and has been interpreted to have been deposited during the Devonian-Carboniferous, the time interval known as a hiatus in stratigraphy of the Korean Peninsula. The mineral composition of the Taean Formation consists mainly of quartz and mica with minor calcite and K-feldspar. The metasandstones are quartzose in nature. Most mineral grains except for quartz are supposed to be of metamorphic origin. The major and trace elements and Sm/Nd isotopic composition of the Taean Formation indicate its provenance being recycled sediment and/or old upper continental crust. Considering detrital zircon U-Pb age distribution reported by previous studies, detritus for the Taean Formation is interpreted to have been supplied from recycling of previously existing sedimentary sources in the western Gyeonggi Massif located to the east of the Taean Formation distribution area.

TECTONO/SEDIMENTARY AND SEDIMENT SOURCE EVOLUTION OF A STEPHANIAN BASIN OF THE FRENCH MASSIF CENTRAL: THE DECAZEVILLE BASIN

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The Decazeville Basin belongs to the Late Carboniferous "stephano-permian" intramontane basins of the French Massif Central. These basins developed in anextensional/strike-slip context as a response to late orogenic collapse of the Hercynian Orogen. The Decazeville Basin is located few kilometers east of the major strike-slip fault of the French Masif Central called "Grand Sillon Houiller". A sedimentary stack of up to 1500 m thickness of Stephanian B and C age (304.5 to 302 Ma) is preserved in the basin. Four formations made of coal-bearing siliciclastic sediments were identified in the basin Infill (in ascending order: Auzits, Banel, Campagnac and Bourran Fms).

The depositional evolution of the Decazeville Basin is two-folded and characterized by migration of depocenters through time associated and drastic changes of the sedimentary system.

Phase 1: The basin initiated during the Stephanian B (Auzits and Banel Fms) with two distinctive depocenters in the southern part of the basin, which join into a single in the northern part. The depocenters are controlled by the west and east border faults. Deposits exhibit typical extensional growth structures associated with drag folds. The sedimentary record consists of hectometric thick fining-upward sequences. These sequences depict an evolution of processes from mass-flow, then debris flow and finally fluvial reworked debris-flow. They are interpreted as alluvial fans systems. In the distal part of the alluvial fans coal seams are interbedded in the alternating conglomerates and sandstones. Sediments are primarily issued from the footwall of the faults and later from more distant sources still in the vicinity of the basin. Paleocurrents are mainly perpendicular to the border faults and are consistent with the interpretation of an alluvial fan system developed on border fault scarps.

Phase 2: Later, during late Stephanian B and Stephanian C (Campagnac and Bourran Fms), sedimentation migrates northward, and a single depocenter in the central part of the basin is controlled by the La Peyrade fault to the west and the Bagnaud fault to the east. The sedimentary infill is made of two finingupwards sequences with coal seams at the top. Sediments are finer than in phase 1. Facies depict debris-flows at the base, evolving to coarse fluvial deposits and finally fine fluvial deposits associated with backswamps/ peatland deposits. Channels interbedded in the coal bearing fine deposits consist in 7 to 10 m thick single storey channels filled by medium to coarse sandstones indicating the drainage system of the basin connected through time to a larger scale drainage system. Sediment size and composition indicate more distant sources than in the first phase. Paleocurrents indicate co-existing transverse and axial drainage in the basin. The deposits of the Bourran and Campagnac Fms unconformably overlie the basin substratum to the east showing the basin covered a wider area than during phase 1.

Through Stephanian B & C times, the Decazeville Basin evolved from a narrow extensional basin associated to alluvial fans fed by locally sourced sediments to a wider single depocentre basin filled by finer deposits depicting larger rivers associated with more distant sediment sources.

TERRESTRIAL TRACE FOSSILS AND SEQUENCE STRATIGRAPHY OF THE FLUVIAL TO MARGINAL MARINE CRETACEOUS BASAL BELLY RIVER GROUP, ALBERTA, CANADA

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Trace fossils produced by air-breathing organisms are useful tools for recognizing exposure surfaces in fluvial to marginal marine settings, especially in cases when these surfaces are not long-lived and pedogenically modied. To test the utility of terrestrial trace fossils in sequence stratigraphy, we studied the fluvial to marginal marine transition in Cretaceous strata from the Alberta foreland basin. Using subsurface cores and well logs from west central Alberta at the Pembina/Keystone elds, we mapped an exposure surface represented by *Taenidium barretti*, which is associated with roots and pedogenic features in landward examples. The surface represents a drop in the water table following forced regression channel incision, and is interpreted as a 5th-order (and possibly 4th-order) sequence boundary. The ~10 m-thick packages in this area typically comprise, from bottom to top, delta-front deposits that are sharply incised by sinuous fluvial channel sandstones and heterolithic facies, followed by pedogenic modication and bioturbation by *Taenidium*. The bioturbated sequence boundary is then typically erosively overlain by clayey mudstones, coal, or an oyster shell lag on the transgressive surface. In some locations, neither *Taenidium* nor roots are preserved on the sequence boundary, which we interpret to signify that in these positions, the channels remained active and were not bypassed during continued base level drop. The most basinward examples preserve a brackish water trace fossil assemblage (e.g., *Teichichnus, Planolites*) in the uppermost sinuous-channel heterolithics, showing autogenic ooding of the channel at the fluvio-marine transition. Subsequently, a monospecic assemblage of *Taenidium barretti* cross-cuts the brackish-water assemblage and demonstrates that the channel was later bypassed, water tables dropped, and that the terrestrial traces represent an allogenic stratigraphic surface. Erosional transgressive surfaces can complicate the recognition of exposure surfaces due to the removal of pedogenic features and rooted horizons. The only evidence of subaerial exposure that might remain is deep-tiered bioturbation, which represents the minimum depth to the water table. In the basal Belly River in the Pembina/Keystone area, the «colonization surface», represented by the traces, indicates that the water table dropped for an extended period of time. In landward examples, the water table dropped by at least 1.5 m, and the traces are associated with other evidence of a relatively well developed paleosol. The most basinward examples of the terrestrial traces on the exposure surface indicate a minimum water table depth of only ~20 to 30 cm. This example from the Alberta foreland indicates that terrestrial bioturbation can be used to: (1) interpret the sequence stratigraphy of fluvial to marginal marine settings; (2) approximate the position of the shoreline; (3) map the positions of active and abandoned channels at the sequence boundary; and (4) help interpret the gradient and topography of channels and interfluve areas at the fluvio-marine transition zone.

COMPARISON OF THE EROSIONAL AND DEPOSITIONAL PATTERNS DURING THE LATE SAALIAN AND WECHSELIAN FROM A SEDIMENT BUDGET ESTIMATION ALONG THE SEINE RIVER (LA BASSÉE)

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The Upper Pleistocene alluvial incised-valley fill of the upstream Seine River alluvial plain, “la Bassée” (between Nogent-sur-Seine and Montereau-Fault-Yonne) is composed of four fluvial sequences, two stepped terraces (Late Saalian (T1) and Wechselian (T2)) and two nested ones (Tardiglacial (T3a) and Holocene (T3b)).

A comparison of the sediment budget associated to the stepped terraces is proposed using the results of the estimations of the incised valley geometry and sediment thickness based on a cokriging of 546 well data and the modern topography. The stratigraphic attribution of the wells is proposed from the geomorphological map. The sediment budget corresponds to the balance between the sediment flux resulting from the erosion of the river catchment, and the sediment storage in the incised-valley that built up the Bassée alluvial plain.

We propose a reconstruction of the extension of the T1 and T2 terraces before the incision by the nested T3a and T3b cycles using the indicator map of the incised surface calculated from the T1 and T2 wells (threshold of 1 corresponds to T1 and of 0 to T2). The estimated T1 surfaces are matching quite well that of the geomorphological map for a threshold of 0.5 and are larger for the lower thresholds.

An estimation of the sediment budgets associated to the T1 and T2 terraces shows that the volume of eroded sediment during the T1 incision (2.1 × 109 km^3) and deposited one (1.3 × 109 km^3) resulted in a sediment export of 0.9 × 109 km^3. The eroded and deposited alluvium volumes during the T2 incision and building of the T2 alluvial beds were nearly half of that associated to T1. The estimation of the present volume of T1 alluvium ranges between 25 to 50% of the incised-valley fill, depending on the threshold.

The preservation of the T1 alluvium along “la Bassée” alluvial plain is uneven. It is controlled by the occurrence of a knickpoint in the middle range stretch of the valley. Upstream of the knickpoint toe, T1 alluvium are well preserved (~50% compared to a mean value of 27% for a threshold of 0.5). They form elongated strips of alluvium dissected by the T2 incision. Downstream of the knickpoint, hardly any T1 remnants are preserved (7%), and the width of the incised valley during the T2 cycle is comparable, if not larger, than the T1 one. Further downstream, the T1 ratio is close to the mean value calculated along “la Bassée” alluvial plain. The pattern of the paleothalwegs, upstream and along the knickpoint face, shows that incision was the dominant process, contrarily to the downstream part of the incised-valley where the sweeping of the valley was more active possibly in relation to the change of hydraulic conditions.

The comparison of the incision and deposition dynamics during the Late Saalian and Wechslian cycles shows that along the Bassée alluvial plain, the processes governing incision and valley fill were more efficient during the late Saalian cycle, suggesting more frequent or longer periods of river instabilities favouring both incision and deposition.

BUILD-UPS AND RHODALGAL CARBONATES ALONG THE QUATERNARY SUCCESSIONS OF THE ADRIATIC AND IONIAN COASTS OF THE ITALIAN PENINSULA

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Carbonate build-ups are limestone bodies that possess topographic relief and that are produced by the action of organisms. These biogenic structures have a significant effect on the seafloor: by increasing the topographic complexity of the environment, they provide shelter to a large number of marine species, creating local hot-spots of biodiversity. Their preservation is a major challenge for environmental protection, especially in the Mediterranean Sea. At temperate latitudes, the growth-rate of most carbonate producers is very slow and consequently their recovery time after damages is very long. Therefore, Mediterranean build-ups are significantly vulnerable to rapid climate changes and anthropogenic disturbances. This issue is particularly critical in the Mediterranean Sea, which is surrounded by heavily populated and industrialized countries. For these reasons, international directives, like the European Habitats Directive and the United Nations ProgrammeMediterranean Action Plan, have listed build-ups as natural habitats of the utmost importance. Coralligenous, *Cladocora caespitosa*, deep-water corals, vermetids, polychaetes and bacteriarelated bioconstructions, which are the most common kinds of Mediterranean build-ups, fall under these directives. Rhodolith beds are also included, since, as much as carbonate build-ups, they also represent important biodiversity hot-spots. Within this framework, this contribution aims to support the ongoing research on recent build-ups and rhodolith beds by providing data on their long-term evolution, through the review of the existing literature on the Quaternary of peninsular Italy. These stratigraphic series recorded the last million years of glacial-interglacial cycles, becoming the perfect archive of environmental variations over the long time-scale. All the reported occurrences of build-ups and rhodalgal carbonates have been summarized in a homogeneous data-set and then analyzed to highlight their distribution patterns in space and time. The analyses consistently outlined the importance of sedimentation rate in controlling the general distribution; most of the reports are concentrated in the southern part of the study area, which is characterized by rivers with negligible sediment load. In the investigated area, during the Quaternary, coralline algae were probably the most common carbonate producer as suggested by the widespread presence of rhodalgal carbonates and coralligenous build-ups. *C. caespitosa* general distribution is mainly controlled by temperature, with most of the occurrences dating back to the warm periods of the late Ionian and of the Tarantian. Large build-ups of *Cladocora* are restricted to embayments and gulfs well protected against storm-waves. The distribution of deep-water-coral build-ups is biased by the geological setting, with most of the reports concentrated in regions characterized by remarkable Quaternary uplift. Chemosynthetic carbonates occur in the northern part of the investigated area, where the seepage of gas and fluids has always been common. Polychaete and vermetid build-ups, as well as stromatolites, are rare in the study area. These results prove that Quaternary sequences hold useful data for the study of modern marine environments. However, further researches are still necessary to fully grasp the effects of nutrients, currents and the other oceanographic variables on the long-time evolution of these Mediterranean habitats.

HEAVY-MINERAL ASSEMBLAGES AS PROVENANCE INDICATORS IN THE JACA BASIN (MIDDLE-LATE EOCENE, SOUTHERN PYRENEES)

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The South Pyrenean basin consists of a synorogenic succession of clastic and carbonate rocks from Late Santonian to Early Miocene age. During Early and Middle Eocene times, fluvio-deltaic environments were restricted to the east (Tremp-Graus and Ager basins), whereby coastal/slope and deep-marine settings spread through the west (Ainsa and Jaca basins). Over this underfilled stage, turbidites dominated in the deep-marine Jaca basin (Banastón and Jaca turbidite systems), bordered by active thrust sheets to the north (hinterland) and carbonate platforms to the south. The Bartonian-Priabonian overfilled stage brought the spreading of transitional (Sabiñanigo Sandstone) and continental settings (Santa Orosia-Atarés alluvial system) throughout the basin. Although provenance constraints for these systems have been based on paleocurrents, basin architecture and sandstone petrography, their heavy-mineral content is not yet known. Aiming to constrain changes in the source area during the basin's evolution, we explore the use of heavy-mineral suites as a provenance indicator in the Jaca foreland basin, by means of Raman spectroscopy coupled with sandstone petrography, and provide new data on the heavy-mineral content. Heavy-mineral analysis (HMA) is one of the most sensitive and widely-used techniques regarding sediment provenance analysis because it provides diagnostic information that cannot be obtained by means of other tools. However, most of the heavy mineral content derived from an orogen is usually dissolved during diagenesis and therefore erased from the sediment record during deep burial. Our results show that the heavy-mineral provenance signature in the northern Jaca basin is masked by intrastratal dissolution during burial diagenesis. Nevertheless, a major heavy-mineral content shift is recorded by opaque grains along the transition from turbidite and shallowwater to continental deposits. The use of Raman spectroscopy for identification of opaque grains, coupled with sandstone petrography, helped to disentangle the interplay between source rock lithology, tectonics and diagenesis of the detrital heavy-mineral suites of the South Pyrenean basin. This allowed to link the compositional change with the onset of the Gavarnie thrust activity, which lead to the uplift and erosion of the preexisting turbidite basin, thus producing a recycled heavy-mineral suite.

EARLY HOLOCENE CHANGES IN CELTIC SHELF EDGE UPWELLING: A COLD-WATER CORAL STORY

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Cold-Water Corals (CWC) like Lophelia pertusa occur along the entire Eastern North Atlantic Margin and are able to form large carbonate mounds. In between the Gulf of Cadiz and the Porcupine Seabight, contemporary CWC growthoccurs at water depths of the permanent thermocline (600 – 1000 m) characterized by a potential density interval ($\sigma\theta$ =27.35-27.65kg/m^3) and a permanent pycnocline between the Eastern North Atlantic Central Water (ENACW) and Mediterranean Outflow Water (MOW) masses, prerequisite to coral larvae dispersal. Interaction between the associated internal tides and the steep continental margin, invoke intensified bottom currents driving the delivery of food particles to the corals. On the Celtic, Armorican and Iberian margins, several enigmatic, fossil CWC "mini-mound" provinces have been discovered at much shallower (250 – 500 m) water depths. U/Th dating reveals two coral growth phases for these mounds, in the early Holocene between 9 and 6 ka BP and in the late Holocene around 1.2 ka BP. In order to investigate the driving processes for the growth of these shallow mounds, time series of ϵNd water mass tracing, Li/Mg thermometry and ^{14}C reservoir ages have been derived from *L. pertusa* fragments of a CWC mini-mound (272 m water depth) on the upper Whittard Canyon shelf edge.

The acquired record exhibits an excursion to more radiogenic ϵNd (-13.16 ± 0.28 to -11.86 ± 0.28), colder temperatures (11.2 ± 0.9 to 10.0 ± 0.9 °C) and increased reservoir ages (60 ± 87 to 804 ± 89 ^{14}C years) between 9 and 7.6 ka BP. This potentially indicates an intensification of upwelling at the Celtic shelf edge which would raise the thermo-and pycnocline, bringing colder and more radiogenic MOW water and increased bottom currents to the shallow CWC's. Increased surface productivity resulting from the upwelling could also have enhanced the food supply allowing sustained mound growth during this period. Contemporary shelf-edge upwelling along the Celtic margin is controlled by the occurrence of large internal tides and seasonal equatorward reversals of the slope current. The eastward extension of the mid-depth Sup Polar Gyre (mSPG) during the early Holocene likely decreased the northward advection of MOW water through the Rockall Trough, analogous to the reduced MOW salinity signature observed during contemporary eastward shifts of the mSPG coupled to the North Atlantic Oscillation (NAO). This could have resulted in more frequent equatorward reversals in the slope current and a more persistent upwelling regime during the early Holocene. Alternatively, a less dense MOW during Sapropel 1 (10 – 6 ka BP) may have shifted the permanent pycnocline to shallower water depth, increasing vertical mixing by internal tides at the location of the CWC mini-mounds on the Celtic shelf-edge.

IS THE SWISS JURA KIMMERIDGIAN MICRITE C AND O ISOTOPIC COMPOSITION OF MICROBIAL ORIGIN ?

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Micrites may be physico-chemically or biologically induced or due to bioclast disintegration accumulation. Most of the Swiss Jura Kimmeridgian micrites contain very little bioclasts. They formed in semi-restricted marine lagoons. Their bulk carbon and oxygen isotopic compositions correlate and decrease throughout the studied interval, suggesting meteoric diagenesis. However, neither isotopic nor elementary analyses performed to date reveal any such diagenetic processes. Carbon and oxygen isotope fractionation between micrites and seawater equals to 0.71. It is constant whatever the age and depositional environment of these micrites, which would have a common origin. The purpose of this study is to unravel the origin of these micrites. They contain microbial facies which have never been studied in detail. Optical and cathodoluminescence microscope analyses show that micritisation, fracturation, cementation, dissolution, precipitation, dolomitisation, mineralization, and stylolitisation occurred. Several generations of cements, fractures, and dolomites were defined. These diagenetic sequences do not contain any evidence of meteoric diagenesis. SEM analyses essentially show dense micrites, made up of fine (from 0.5 to 2.5 µm) subhedral to anhedral crystals with fully coalescent to fused contacts. The samples analysed also contain various organic remains of microbial origin such as cell-shape bodies, microorganism colonies or extracellular polymeric substances (EPS). Elemental analyses of these remains reveal high content in carbon, magnesium, aluminium, and silicium that supports their microbial origin. These remains mostly line the edges of the depressed parts of the surface, suggesting that they were the starting point for biomineralization processes. Three hundred and ninety-nine SIMS carbon and oxygen isotope analyses were performed in the 3 samples (namely Pi 83, 96, and 98) that contain the most diversified and abundant microbial types. Transmitted light microscope analyses of these samples show that they contain more or less dark-coloured phases. As Pi 96 shows the lowest $\delta^{13}C$ and $\delta^{18}O$ variations, analyses were performed in priority on Pi 83 and Pi 98. $\delta^{13}C$ values range between -9.74 and 0.18‰ VPDB in Pi 83, and between -11.66 and -2.31 in Pi 98; $\delta^{18}O$ values range between -18.18 and -8.84‰ VPDB in Pi 83, and between -17.91 and -8.16 in Pi 98. The lowest $\delta^{13}C$ values characterize the darkest phases. In Pi 83, where the largest number of measures were realised, statistical analyses (MANOVA and ANCOVA) confirm that C and O isotopic compositions characterize the darkest phases that show the same C and O fractionation than that acquired from bulk rocks (0.855 in Pi 83 and 0.71 in bulk rocks). MEB and elemental analyses show that the darkest phase may coincide with the depressed parts of the surface and high content in carbon, magnesium, aluminium, and silicium, both characterizing the organic remains identified in the samples analysed. These preliminary results indicate that 1) the studied samples contain preserved fossil microbial remains closely associated with carbonate minerals; 2) these microbial facies show the same C and O fractionation than that measured in bulk rocks; 3) such fractionation points toward a common microbial origin for the Kimmeridgian shallow-marine micrites of the Swiss Jura.

CHARACTERIZATION AND STRATIGRAPHIC CORRELATION OF THE MCE1 IN SE FRANCE

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The " Mid Cenomanian Event 1 " (MCE1) is a major perturbation of the carbon cycle, characterized by two $\delta^{13}C$ positive peaks: 1a and 1b. It was recognized in the Vocontian Basin (Blieux section). There, the onset of MCE1 has been associated with major relative sea-level fall, arid climatic and oligotrophic conditions. In order to give further support to these environmental and climatic interpretations, three shallow-marine successions (Caussols, Col des Abbesses, and Le Bourguet) were studied; they are located to the South of the Vocontian Basin, on the northern part of the Durancian Isthmus. Field, facies, carbon isotope, and clay mineral assemblage analyses, ammonite and calcareous nannofossil biostratigraphy, sequence stratigraphy, and correlation of these mixed carbonate-siliciclastic sections have been made.

A complete data set was acquired in the most proximal Caussols section that was chosen as a reference. This section is 80 m thick and includes 3 successive parts (presented in the stratigraphic order): the first part is composed of silty marl-limestone alternations; the second part is characterized by bioclast-rich silty limestone; and the third part is marl-dominated. The second bioclastic and calcareous part contains orbitolids, oysters, gastropods, and undifferentiated bivalves. The orbitolid disappearance coincides with the lower-middle Cenomanian boundary and the MCE1 onset, both identified in this section. This substage boundary and the MCE1 were also recognized in the Col des Abbesses section, which is 180 m thick and subdivided in 2 parts: the first part is composed of sandy alternations of marl and yellow laminated limestone; the second part includes white silty marl-limestone alternations. In the first part, cross, plane-parallel and hummocky-cross stratifications indicate sediment current and wave reworking. The first part also shows strongly deformed limestone beds that are interpreted as seismites. The second part begins in the upper part of the lower Cenomanian and ends in the middle Cenomanian. Both parts contain orbitolids, which disappear just below the lower-middle Cenomanian boundary as it was observed in the Caussols section. The Le Bourguet section is 260 m thick and includes 3 successive parts: the first part contains silty alternations of marl and limestone; the second part, sandy alternations of marl and yellow laminated limestone, and the third part, bioclast-rich sandy alternations of marl and yellow laminated limestone. Seismites are observed in the second part. Orbitolids occur in the third bioclastic and sandy part in association with oysters, serpulids, gastropods, and undifferentiated bivalves.

This preliminary correlation of three Cenomanian shallow-marine successions of SE France shows that the orbitolid occurrence and disappearance are not related to a specific sedimentary facies. Their disappearance would result from particular environmental, such as changes in relative sea level and/or climatic conditions corresponding to the MCE 1 onset. Several hypotheses are developed on the basis of the large database acquired in this work.

STROMATOLITE FRAMEWORK BUILDERS OF A CRYOGENIAN REEF

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The development of a carbonate reef on the eastern margin of the Adelaide Geosyncline in a period bracketed by two mid-Neoproterozoic (Cryogenian) global glaciations reflects the concurrence of extrinsic factors, including: low (~ 8°) palaeolatitudal position, palaeotopographic situation at a rift margin, relative sea level shallowing following prolonged basin wide post-glacial transgression, and likely reestablishment of seawater carbonate saturation following post-glacial carbonate sequestration as 'cap carbonate' immediately succeeding the earlier Sturtian glaciation. Conditions conducive to carbonate precipitation, deposition and preservation, therefore, facilitated initiation and sustained growth of an ~350 m thick carbonate reef with a framework dominated by a variety of stromatolite forms.

Detailed field mapping along with cross-sectional exposure through the internal architecture of Arkaroola reef in the northern Flinders Ranges, South Australia, reveals a spatially and temporally variable stromatolite assemblage. The range of forms reflects ecological succession from microbial biostrome colonization through to a climax community of domal, columnar and digitate stromatolite forms. Growth of wrinkly-laminated, m-thick, microbial biostromes, 10s to 100s m in extent, initiated development of a stable carbonate substrate on underlying thick muds. These biostromes mark the windward margin of an incipient reef, with spatial arrangements similar to spur and groove structures of modern windward reef margins. Once stabilised, a robust reef framework developed, first through growth of 1-3 m-scale domical and linked columnar stromatolites forming large stacked bioherms of many metres topographic relief at the reef front. This biological modification of local environmental conditions lead to an ecological succession of stromatolite forms in response to substrate stabilization, wave-energy baffling and aggradationally driven shallowing. The spatial and stratigraphic distribution of a range of centimetre-to decimetre-scale columnar, domal and digitate stromatolites, in conjunction with intraclastic, peloidal and oolitic grainstone and packstone facies characterises development of a reef flat and leeward lagoon. Variability of stromatolite forms across the reef morphology indicates ecological adaptation of function and structure responding to local differences in factors such as light, nutrient supply, hydrodynamics, water clarity and tidal exposure.

Microbial (stromatolite) growth in a range of forms overwhelming controlled carbonate production resulting in both a biogenic framework and eroded and redistributed bioclast deposits across the reef. The range of stromatolite forms and their facies distribution within the reef is consistent with biological control on ecosystem development and stabilisation as seen in Phanerozoic and modern reef ecosystems. The Arkaroola reef exhibits analogous ecological succession in a late Proterozoic stromatolite evolutionary realm. Furthermore, Arkaroola reef records a period of relative climatic and sea level stability in a geological period notable for severe climatic upheaval.

CONSEQUENCES OF THE OI-1 EVENT ON THE CARBON CYCLE: THE CENTRAL MEDITERRANEAN RECORD

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At the Eocene-Oligocene transition the Earth faced a critical step in the climatic evolution, passing from the greenhouse climate of the early and middle Eocene through a transitional period in the late Eocene to the modern icehouse climate. This transition is marked by a sharp positive oxygen isotope peak, known in literature as Oi-1 event, which testifies the onset of the glaciation in Antarctica. This event is coincident with a decreasing of atmospheric CO_2 concentrations, and has been immediately followed by a positive carbon isotope shift, testifying the complex interplay between climate evolution and global carbon cycle. The aim of this work is to identify how the carbonate successions of the Central Mediterranean area recorded this major climatic event and carbon cycle perturbation. Two different carbonate successions will be analysed and discussed. The shallow-water record has been investigated on the northern sector of the Apulian Platform (Majella Mountain, Central Apennine), while the Massignano section (Riviera del Conero, Central Italy), GSSP of the Eocene-Oligocene boundary, has been chosen to study the basinal signal. A detailed stratigraphic study and facies analysis have been performed on the shallow-water carbonates, before measuring carbon and oxygen isotope ratios on whole-rock samples. The stratigraphic framework of the Apulian Platform succession is provided by calcareous nannofossil biostratigraphy. As for the basin record, the Total Organic Carbon (TOC) has been analysed in the Massignano section, since it was a missing record for the GSSP of the Eocene-Oligocene boundary, and proved to be an extremely useful tool to complement the carbonate C-isotope analyses and to understand the C-cycle perturbations. Our promising preliminary results show a decreasing trend in the platform carbon isotope curve in upper Eocene interval, in agreement with the global record, while the succession is interrupted by a massively slumped interval at the base of the Oligocene. The basinal TOC carbon isotope record shows an overall increasing trend of the carbon isotope ratios, punctuated by short term negative peaks, during the late Eocene, while a sharp negative spike is recorded at the base of the Oligocene, testifying a distinct trend reversal which might be triggered by an increased primary productivity within the Central Mediterranean waters.

SUPERCRITICAL-FLOW BEDFORMS AND SEDIMENTARY STRUCTURES DISTRIBUTION ANALYSIS, IN A CHANNELISED LOWER-SLOPE, A BASE-OF-SLOPE, AND PROXIMAL BASIN-FLOOR, MIDDLE EOCENE, AINSA BASIN, SPANISH PYRENEES

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The Banastón System (Middle Eocene, Ainsa Basin, Spanish Pyrenees) shows deep-marine deposits of a channelised slope and proximal basin-floor setting whereas the Ainsa System (Middle Eocene, Ainsa Basin, Spanish Pyrenees) shows a transition from lower-slope erosional channels to proximal basin-floor channels and related deposits. The Ainsa System contains finer grained sediments compared with the Banastón System. In recent years, many researchers have focussed on supercriticaland subcritical-flow deposits using flume-tank or from direct observations on presently active deep-water systems. Using outcrop examples from the Banastón and Ainsa systems, associated with published experimental works, a range of deposits are interpreted as upper-flow regime bedforms (stable antidune, unstable antidune, chutes-and-pools and cyclic steps) and sedimentary structures (upflow-inclined cross-lamination, upflow-inclined spaced stratification and parallel lamination). This contribution focusses on (i) a description and interpretation of several supercritical-flow bedforms and sedimentary structures, and (ii) an analysis of the distribution of the supercritical-flow deposits linked with depositional environment at two different scales: intra–system (channel-axis, off-axis, channel-margin and interfan), and between the Ainsa and Banastón systems (with the latter containing a greater amount of more proximal basin-slope deposits).

ALLOCHTHONOUS SLOPE AND BASINAL CARBONATES ADJACENT TO ISOLATED PLATFORMS IN THE MOZAMBIQUE CHANNEL: STRATIGRAPHIC ARCHITECTURE, DEPOSITIONAL CONTROLS, AND IMPLICATIONS FOR CARBONATE FACIES MODELS

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Newly acquired high-resolution seismic, bathymetric, and core data from the Iles Eparses (Mozambique Channel, southwestern Indian Ocean) reveal new information about carbonate sediments transported into the deep sea from isolated platforms. Steep (~40°) upper platform slopes consist primarily of outcrops of volcanic basement, erosional scarps, and shallowly incised channels that funnel shallow water carbonate sediments to the sea floor up to 3000 meters deep. Lower slopes (~5°) and basin floor deposits extend up to 20 km from platform margins and consist of erosive amalgamated leveed channel systems, mass-transport complexes, turbidite fans, and plastered contourite drifts. In seismic, proximal wedge-shaped debris flows can be clearly seen to terminate at slope bases, or grade distally into unconfined turbidites that are composed primarily of graded and massive bioclastic grain-stones with abundant shallow-water (neritic) skeletal components. Recently deposited sediments are distributed radially on all sides of each platform, but sedimentation on leeward slopes is often more dominant. Depositional processes are primarily gravity-driven, however, deposits are variously affected by bottom currents and may interact with nearby clastic slope systems. Slope and basinal deposits are also influenced by the tectonic setting and the distribution of geomorphologic elements on the platform top. All of these features are critical in a complete source-to-Sink understanding of carbonate deposition-the geomorphologies, stratigraphic architecture, depositional processes, and sedimentation controls discussed here are different than those described in carbonate slope systems in the Bahamas and elsewhere. By expanding the knowledge of deepwater gravity-deposited carbonates to these previously unknown examples, this study has the potential to significantly impact carbonate depositional models, and to provide new analogues for similar deposits in the geologic record.

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DEVELOPMENT OF ISOLATED CARBONATE PLATFORMS IN ACTIVE GEODYNAMIC SETTINGS: NEW INSIGHTS FROM THE MOZAMBIQUE CHANNEL (SW INDIAN OCEAN)

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Although the impact of geodynamic activity on the long-term evolution of shallow-water carbonate platforms has been the subject of numerous studies during the last decades, the driving processes and involved interactions are still deeply debated. The Mozambique Channel, located between East Africa and Madagascar continental margins, is characterized by several flat-top seamounts and terraces currently lying at several hundred meters deep. Based on a varied oceanographic dataset, including bathymetry DEMs, submarine videos, dredged rock samples and multi-resolution seismic, our study revealed that these submarine edifices correspond to drowned isolated shallow-water carbonate platforms that originally settled on volcanic substrates. These drowned carbonate platforms are structured through high-offset normal faults networks into distinct structural blocks, and are locally covered by volcanic material and morphologies implying both effusive and explosive eruptions. Coupling strontium isotopic stratigraphy and foraminifera biostratigraphy, well-constrained chronostratigraphic results indicate that shallow-water carbonate production mainly occurred during Oligocene and Miocene times. Biological assemblages were dominated by corals, larger benthic foraminifera, red and green algae, thus indicating typical tropical and clear waters settings probably associated, at least temporarily, to reef systems. The drowning of these isolated carbonate platforms, which is revealed by the deposition of Early Pliocene outer shelf sediments seems closely linked to (1) high rates of accommodation creation induced by extensional tectonic and/or (2) environmental perturbations related to volcanic activity. Locally, shallow-water carbonate sedimentation resumed during Late Neogene times with the colonization of topographic highs inherited from tectonic deformation and volcanic accretion. In the southern Mozambique Channel, final carbonate growth phase led to the development of a modern atoll. The location, timing and nature of the Late Cenozoic geodynamic activity observed along the studied isolated carbonate platforms tend to emphasize the influence of the East African Rift System until the southern Mozambique Channel. The reconstruction of the Mozambique Channel carbonate platforms evolutions provides great illustrations of tight interactions between shallow-water carbonate sedimentation and geodynamic activity in isolated oceanic settings.

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LATE PLEISTOCENE SEDIMENTARY RECORDS IN THE JAPAN SEA / EAST SEA: EVIDENCES OF ASIAN LOESS INPUTS DURING THE MIS 22 GLACIATION

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Monsoon is an important atmospheric phenomenon affecting a large part of the world's population with very strong climatic cycles between dry and wet seasons. Moreover, recent climate changes highlight the need for a better understanding of long-term monsoon variability for the last millennium. Several studies have been conducted on the East Asian Monsoon variability in last decades through the Chinese Loess, the East China Sea and the Japan Sea marine sedimentary records.

The Expedition IODP 346 ("Asian Monsoon", July-September 2013) was operated with the objective to acquire new data for studying the millennial variability of the East Asian Monsoon and better understanding on its control mechanisms.

This work is focused on the site U1427, located in the South Japan Sea (Yamato Basin, 330 m bsl) at 35 km from the northern coast of the Honshu Island. This site is the shallowest site of this expedition with a high sedimentation rate of ~300 m/my. that provides an extremely high resolution record spanning most of the Pleistocene. East Asian Monsoon (EAM) is constituted by two annual phases: a winter monsoon with strong and cold winds from Siberia and the summer monsoon with warm and humid winds from the Bay of Bengal in the SoutH.

Oceanographic conditions in this region are also largely influenced by the sea level changes. Therefore, the drop of the sea level (more than 100 m) during major glacial phases have led to an isolation of the Japan Sea from the East China Sea, North Pacific Ocean and Okhotsk Sea because of the four shallow sills forming the actual straits (Tsushima, Tsugaru, Soya and Tatarskiy Straits). During low sea level conditions, the Japanese islands and inter island shallow straits (sill depth less than 130 m) have limited seawater exchanges leading to poorly oxygenated conditions of water masses in the Japan Sea. We have combined the study of benthic microfauna (ostracods) and micro-sedimentary facies, in order to characterize the oceanographic conditions in relation to climate and sedimentary processes registered in the U1427 borehole from MIS 20 to MIS 36. Major results of this study can be summarized as follow:

During the glacial periods, the benthic population of ostracods is absent. This result is consistent with low oxygen bottom water conditions in the Japan Sea, possibly due to restricted exchanges with the East China Sea. During one of the most intense glacial phase (MIS 22), the presence of millemetric laminations is observed formed by alternation of fine-grained dark sediments and coarser (silt) grained light laminae that might correspond to annual or seasonal cycles in the EAM. The coarse grained laminae have been observed using a SEM technique and reveal peculiar features suggesting that the light-color grains can be interpreted as loess transported by wind and/or oceanic current. We advance the hypothesis that during winter monsoon strong and cold winds might have transported these grains from the Tibetan Plateau, which demonstrates the importance of the East Asian Monsoon in the transport of the Asian dust during the major glaciations.

WHEN DID THE WEICHSELIAN GLACIERS REACH THEIR MAXIMAL EXTENSION IN THE FRENCH WESTERN ALPS ? NEW DATA, NEW AGES, NEW IDEAS

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Since the pioneering work of Penck and Bruckner (1909), two morainic complexes have been recognized in the marginal zone around the Alpine chain and the Jura Mountains. Those two morainic complexes were attributed to the Riss (Saalian; 325 ky to 130 ky) and to the Würm (Weichselian; 115 ky to 10 ky) glaciations. Since then most of French authors have separated the Würm period in 3 stages (Würm I to Würm III) according to field evidences. However, this relative chronology makes correlations between tills from different places difficult because those stages are only exposed in few places on the same vertical section. Based on a compilation of previous geochronological data published since half a century in the French Western Alps, the age of the maximal extent of Würm glaciation (WM) is suspected to be older than the classical Last Glacial Maximum (LGM) or Marine Isotopic Stage (MIS) 2. In the present contribution, we expose preliminary results from new single grain Optically Simulated Luminescence (OSL) and ^{14}C dates from two areas in the French Western Alps: the Trièves area, south of Grenoble, and the Val Bourget area, near Chambéry.

The Trièves area was not covered by ice during the Würm. It was dammed by a glacier during its maximal extension which created a large lake. A sedimentological study (grain size, loss of ignition, magnetism, etc.) was carried out on two geotechnical boreholes (26 and 59 m long) and outcrops. Close examination of the cores did not allow to find any plant macrorests. Then ^{14}C datings were performed on bulk material. Two samples were collected in a thick sandy layer close to the base of the lacustrine deposits. OSL results suggest that the growth of the glacier started at ca 40-45 ky. ^{14}C dates are in agreement with OSL results and show a consistent younging trend versus elevation. The youngest age is around 30 ky cal BP and is attributed to the upper part of the lacustrine sequence.

In the Lake Bourget area, two OSL dates were obtained from an outcrop showing plants remains. It was possible to identify cones of spruce (Picea). This outcrop is over consolidated and was previously dated as Eemian because of well preserved and known interglacial lignite layers in this area. Ages around 43.8 ±6 ky suggest that it could possibly be contemporaneous with peat from Niederweningen in Switzerland and suggest that Val Bourget was not glaciated at that time.

These new data appear in good agreement with other dates collected in the French western Alps. In this area, it is then possible to bracket the age of the WM period between around -45 and -30 ky. This is clearly different from the classical assumption of a WM contemporaneous of MIS2 (between -25 and -20 ky). The preliminary data presented here suggest that the WM is diachronous at the scale of the Alpine belt. Consequences on paleoclimatic reconstitutions and paleoatmospheric circulations have to be investigated further.

MAGNETIC CHARACTERIZATION OF INSTANTANEOUS SEDIMENTARY DEPOSITS: EXAMPLES FROM ALPINE LAKES

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In lake sediments, study for paleohazard reconstructions, one of the main target is the identification of instantaneous deposits and their triggers (e.g. flood, mass movement). Those deposits are classically evidenced using grain-size and geochemical analyses But their trigger are often a debating issue because of the lack of unequivocal evidences. In this context, magnetic measurements may provide additional information to improve our understanding of such deposits. In the late 90th, the wellknown AD 1822 homogenite from Lac du Bourget (France) has been characterized by a high value of AMS foliation. Since this time, only few magnetic investigations were carried out on such deposits. Campos et al. (2013) have shown in the Sea of Marmara and Gulf of Corinth that homogenites can be differentiated from hemipelagites using their high ASM values. Other magnetic investigations are focussing on the record of Remanent Magnetization in the turbidite.

In the present contribution, we will develop the anisotropy of magnetic susceptibility (AMS) and magnetic mineralogy in order to evidence mass-movement-induced turbidites (MMIT) in some selected French alpine lakes MMIT have been sampled for a specific magnetic study in several alpine lakes: Le Bourget, Savine, Vens, Foréant. The sedimentary archive of Lake Vens reveals 6 successive homogenites in a 150 cm long core, which are well highlighted by magnetic parameters. The sedimentary record of Lake Foreant provides 171 event layers. Magnetic data from this sedimentary sequence allow the identification of specific layers which are interpreted as MMIT seismically induced. The lake Savine (Sabatier et al., in press) exhibits 20 of 220 deposits that are suspected to be triggered by earthquakes.

For almost of these MMIT, a strong planar disposition of magnetic particles (AMS) has been observed and interpreted as the result of the oscillations of the water mass during the slow decantation of re-suspended material. But, on the other hand, several paleolake deposits show the same kind of planar disposition. In this case, one can claim that compaction due to the weight of overlying sediments should explain the observation. This hypothesis will be discussed at the light of the magnetic mineralogy of paleolakes sediments, MMIT and flood deposits. This comparison will help the interpretation of those particular layers in future paleohazard studies.

LINKING FACIES AND GEODYNAMICS: THE JAIZQUIBEL EOCENE TURBIDITE SYSTEM REVISITED (GUIPUZCOA, PYRENEES)

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The Jaizquibel turbidite system has been intensively studied by many geologists since the pioneer work of Van Vliet. The range of turbiditic facies described by Van Vliet was revisited in light of the Mutti facies classification on ancient turbidites. A particular emphasis was put on the distinction between hyperconcentrated flows and turbulent flows linking the key F6 facies that record the change in "turbiditic" flow behavior.

In the Jaizquibel system, coarse grained wave-like bedforms are exceptionally preserved. These facies are genetically related to F6 facies. Similar kind of facies with hummocky like structures and large bedforms was described by Bravo in the Albian Flysch of Vizcaya but few examples have been described somewhere else. These structures are related to decelerating supercritical flows associated with mud pebbles filled scours passing to F6 tractive bedforms.

The basin since the Aptian-Albian initiated from rifting in the Bay of Biscay followed by a later stage of collision between the Iberian and the European plate resulting in a transition from extension to compression. The occurrence of the sand rich Jaizquibel fan in the Eocene remains enigmatic due to its Northern provenance opposite to the emergent Pyrenean orogen. Interpreted subsurface seismic data provide key information to understand the Jaizquibel sand origin in the regional tectonic setting and its peculiar range of facies.

Earlier works in the area (Van Vliet, Rosell, Crimes, Pujalte, Petrissans, Payros and others) focused precisely on stratigraphic aspects of the Eocene Paleogene turbidite sequence. The amount of sand and the orientation of the Jaizquibel system indicate a tectonic overprint on eustasy influencing sediment supply especially when comparing with the fine grained distal part of the Hecho Group. (Payros, Pujalte, Remacha). By integrating subsurface data to facies observations, a short distance origin of the sediments in relation with the cannibalization of the Landes high is better demonstrated with erosion of former Cretaceous and Paleozoic rocks.

The Jaizquibel fan origin and its associated facies track become more comprehensive also by integrating this system into the geodynamic context and by comparing with other Eocene turbidite systems along the Pyrenees. These others turbidite systems have also a non-orogen parallel orientation. The NE-SWoriented Pamplona "fault" limits the relative motions of two main segments during the Eocene. Indeed, the eastern segment records a rapid flexural subsidence whereas the western block remained under shallow-marine environment (Payros, Pujalte Larrasoaña) to the South and reversely to the North around Bayonne. This is noteworthy that other similar hinge zones parallel to the Pamplona fault occur also offshore bordering the Landes high.

The Jaizquibel system is seen as one of the left behind product of the early inversion with a nonorogen parallel orientation such as other non coeval systems: Anotz Formation, Rapitan or Eskaba Sandstone (Remacha, Payros). From this study, we can conclude that the inherited segmentation of Albian basins plays an indirect control on the future location and virgation of the Paleocene basin axial deep water systems and the sourcing of the Jaizquibel Eocene turbidite systems around transfer zones.

FLUID-ROCK RELATIONSHIPS DURING THE FORMATION AND INVERSION OF AN EXTENSIONAL BASIN (UPPER PEDRAFORCA THRUST SHEET, SOUTH PYRENEAN FOLD AND THRUST BELT)

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The South Pyrenean fold and thrust belt (NE Spain) is an excellent example in which the relationships between fluids and sedimentary basins during the Mesozoic extension and Pyrenean orogeny can be studied.

This study is focused in the Upper Pedraforca thrust sheet, emplaced from Late Cretaceous to Paleocene. This structure consists of an extensional basin related to the diapirism affecting the Iberian Margin during Mesozoic times which was inverted during the Pyrenean compression. The main thrust places synrift Lower Jurassic to Upper Cretaceous limestones and dolostones over syn-orogenic Upper Cretaceous to Paleocene carbonates and clastic sediments.

Intergranular and vug porosity, joints, reverse and strike-slip faults acted as preferential paths for fluids during the Mesozoic extension and the Upper Cretaceous to Paleocene compression. The diverse generations of calcite cement precipitated recorded the geodynamic evolution of the Upper Pedraforca thrust sheet.

During the Mesozoic extension, calcite with a $\delta^{18}O$ of -9.6 ‰ VPDB and $\delta^{13}C$ of -3.1 ‰ VPDB precipitated in extensional fractures affecting laminated Lower Jurassic limestones. These veins are cut by bed-perpendicular joints filled with calcite ($\delta^{18}O$ between -11.7 and -8.9 ‰ VPDB and $\delta^{13}C$ between -1.1 and -0.9 ‰ VPDB), which precipitated from hot fluids. Within these veins, rhomb shaped dark crystals of calcite ($\delta^{18}O$ of -7.4 ‰ VPDB and $\delta^{13}C$ of -2.3) are observed. During the same period, carbonate breccias interbedded with Jurassic limestones and cemented with meteoric calcite ($\delta^{18}O$ between -7.7 and -6.7‰VPDB and $\delta^{13}C$ between -1.2 and -0.5 ‰ VPDB) indicate that these sediments were periodically exposed during relative sea level falls.

During the Upper Cretaceous to Paleocene compression, hot fluids with increasingly meteoric influence migrated along vug porosity, joints and reverse and strike-slip faults from the Upper Pedraforca thrust sheet to its associated foreland basin, recording the progressive emersion of this structure. This evolution of fluids is evidenced by the progressive depletion in $\delta^{18}O$ and $\delta^{13}C$ of calcite cements precipitated in reverse and strike-slip faults, from -5.5 to -13.6 ‰ VPDB and from +1.9 to -10.04 ‰ VPDB respectively.

DEATH OF A TROPICAL CARBONATE PLATFORM: STUDY CASE OF THE CARBONATE SHELF OFF THE AMAZON RIVER, BRAZILIAN EQUATORIAL MARGIN

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This study addresses the Miocene to Recent continental shelf sedimentary record of the Amazon River Mouth Basin located off the Amazon River. A mixed carbonate-siliciclastic platform was established during the Late Paleocene in the basin mid-outer continental shelf, while siliciclastic sediments were trapped in the inner shelf. This scenario lasted until the Late Miocene when the mid-outer shelf witnessed a transition from predominantly carbonate sedimentation to an almost purely siliciclastic sedimentation. In the present work, we have refined the age model for the Cenozoic sedimentary succession of the offshore Amazon basin, based on the revision of the available micropaleontological data from industry wells and by comparing them with recently published astrochronologically-calibrated ages, considering the first and the last appearance of key planktonic species. Such work allowed us as well to establish a new age model for the carbonate sedimentation, including a more precise time for the carbonate production cessation in the basin, which was also tentatively correlated with eustatic sea-level curves. The resulting age model attests that the carbonate sedimentation ceased and was replaced by terrigenous sediments on the central and southeastern margin between 9.1 and 7.78 Ma (probably ~8 Ma). However, towards the northwestern margin, carbonate production persisted until around 4.0-3.8 Ma, pointing to the occurrence of a smaller flux of siliciclastic sediments into that area. Longer-lasting carbonate sedimentation on the NW carbonate platform can be probably explained by the presence of a ~150 km wide reentrant embayment formed in the margin's central region during the Early-Middle Miocene, due to higher local subsidence rates, probably related to the existence of deep grabenslike structures inherited from the rifting phase. As a result, the shelf-edge backstepped in the central basin, forming a large embayment which connected the main source of terrigenous sediments from the paleo-Amazon river directly with the deep-basin. In such a scenario, the central basin became separated from the NW carbonate platform where local carbonate production was able to keep up with base level oscillations as the shelf-edge remained distally positioned located on a more stable region. Finally, during the Early Pliocene, a fraction of the paleo-Amazon river sediments was able to reach the NW region carried alongshore in the innermost shelf as indicated by a ~80 m thick prograding wedge. In the latest Early Pliocene most of the embayment between the central and northwestern shelf's region became filled up by sediments delivered by the paleo-Amazon river when a combination of sea-level lowering and gradually higher volumes of terrigenous sedimentation rates finally promoted the burial of the previously carbonate-dominated environments across the entire basin. From the Late Pliocene onwards, only narrow reef-like features are locally recognized on the seismic data. These carbonates are usually 1 to 3.5 km wide but can reach more than 55 km in extension along the present and the paleoshelf break, attesting for reduced terrigenous influx into the outer shelf during interglacial marine transgressions.

A STRATIGRAPHIC MODEL OF THE UPPER MIOCENE-PLIOCENE BASIN FILL OF THE PANNONIAN BASIN, EASTERN HUNGARY: RESULTS FROM SEQUENCE STRATIGRAPHIC INTERPRETATIONS AND MODELING

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The Pannonian Basin is an extensional tectonic setting, formed by rifting in the Middle Miocene and post-rift thermal subsidence and tectonic inversion from late Miocene up to the present. The objective of this study is to contribute to the understanding of the late Miocene-Pliocene stratigraphy by presenting new subsurface interpretations and stratigraphic modeling for the basin fill where large part of the hydrocarbons accumulated. The total initial in-place hydrocarbon reserves in Hungary in the national registry include 230.6 million tons conventional and 418.9 million tons unconventional oil reserves, 192.9 billion m^3 conventional and 3,923.3 billion m^3 unconventional gas reserves. Our study may particularly be relevant for developmental projects of unconventional fields.

Subsurface geological data show that a prominent unconformity surface formed during Messinian time in the Pannonian Basin associated with a sudden forced regression, abrupt basinward shift of facies and a subsequent, prolonged lowstand normal regression. The lowstand prograding series filled up the shallow basin fast, while, at the same time, the marginal areas of the basin were subject to tectonic inversion. Dionisos stratigraphic modeling program used in this research is built on a nonlinear water-driven sediment diffusion process, and it employs multiple sediment classes, basin flexure and compaction. Four different scenarios were built in the experiments to test possible basin histories with different rates and timing of tectonic inversion. Each scenario was modelled in two versions: including and not including a lake-level fall in the Messinian. The results confirm that the Pannonian Basin in the study area has undergone a tectonic inversion since the Messinian, although the exact rates of uplift at different locations remain uncertain. The unconformity and the observed stratigraphic architecture and facies pattern could be modelled adequately only in the versions that applied a Messinian lake-level fall.

Three fluvial systems overfilled the basin: a large system from the northeast, another from the northwest and a third smaller system transported sediments from the southeast. Large part of the basin had been filled by Messinian time (late Miocene); the remaining lake was located in southeastern Hungary and neighboring countries. In the Tortonian stage, the three fluvial systems advanced concomitantly (with small-scale, high-frequency cycles), toward the basin center.

USE OF MULTIBEAM-BATHYMETRY AND SEISMIC-REFLECTION DATA TO INVESTIGATE THE ORIGIN OF POCKMARKS ALONG THE SOUTHEASTERN FLORIDA CARBONATE PLATFORM

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Numerous large, semicircular, deep submarine depressions on the seafloor of the Miami Terrace (a bathymetric bench that interrupts the Atlantic continental slope on the southeastern carbonate Florida Platform) have been described as submarine sinkholes resulting from freshwater discharge at the seafloor and dissolution of carbonate rock. Multibeam-bathymetry and marine, high-resolution, multichannel 2D and 3D seismic-reflection data acquired over two of these depressions at water depths of about 250 m (“Miami sinkhole”) and 336 m (“Key Biscayne sinkhole”) indicate the depressions are pockmarks. Seafloor pockmarks are concave, crater-like depressions that form through the outburst or venting of fluid (gas or liquid or both) at the sea floor and are important seabed features that provide information about fluid flow on continental margins. Both the “Miami sinkhole” and “Key Biscayne sinkhole” (about 25 and 48 m deep, respectively) have a seismic-chimney structure beneath them that indicates an origin related to seafloor fluid expulsion, as supported by multi-attribute analysis of the “Key Biscayne sinkhole”. Further, there is no widening of the depressions with depth as in the northern Fort Worth Basin, where widening of similar seismic, sub-circular, karst-collapse structures is common. However, hypogenic karst dissolution is not ruled out as part of the evolution of the Miami Terrace depressions. Indeed, a hypogenic karst pipe plausibly extends downward from the bottom of the “Key Biscayne sinkhole”, providing a passage way for focused upward flow of fluids to the seafloor. In the "Key Biscayne sinkhole”, the proposed karst pipe occurs above the underlying seismic chimney that contains flat bright spots (a hydrocarbon indicator) in the seismic data showing that plausibly fluids (gas or liquid or both) are currently trapped. The Miami Terrace depressions have seismic-reflection features similar to modern pockmarks imaged on the Maldives carbonate platform. The seismic-reflection data also show that ancient sea-floor expulsions are present within the southeastern Florida Platform as indicated by buried pockmarks. Additional processing of the 3D seismic data will aid in elucidation of the origin of these seafloor depressions.

DISTINGUISHING ENVIRONMENTAL SIGNALS IN A SYN-OROGENIC, VOLCANICLASTIC TO EROSIONAL ENGINE SEDIMENT ROUTING SYSTEM: A CASE STUDY FROM THE PATAGONIAN FORELAND, ARGENTINA

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The analysis of the controls in the sedimentation and surface processes into integrated, cause-effect models are in the spotlight during last years. The sedimentary record has been long used to analyze the deformation and determining climate proxies at different temporal-spatial scales, motivating works focused on to detect the tectonics and climate impact in non-marine basins infill. From the perspective of sedimentary system analysis, signals were defined as changes in sediment production, transport, or deposition that originate from perturbations of environmental variables for several timescales. However, relatively few studies have considered the volcanism into all these schemes. This work examines the syn-orogenic Miocene succession in the Southern Patagonian Broken-Foreland, Argentina, in an attempt to understand the coupling effects of volcanism, tectonic and climate controls to set signals in a complex sediment routing system (SRS). Based on a multidisciplinary approach, which includes structural analysis, facies model, palaeosol analysis, sequence stratigraphy, together with Digital Outcrop Modeling (*DOM*) and geochronology techniques, the main goals of this study are to analyze: (1) how in a syn-orogenic context the volcaniclastic supply affects the climatecontrolled erosion, and (2) how it affects environmental signals.

The Miocene (21–9 My) foreland infill megasequence (*FIMS*) of the Southern Patagonian BrokenForeland shows four major regional extended discontinuity surfaces. Facies analysis determined that the main sediment transfer systems to the *FIMS* correspond to alluvial–fluvial/alluvial–palustrine environments. The recognizing of local unconformities allowed to divide the *FIMS* in 6 depositional sequences (*DS*). Structural and *DOM* analyses determined inter-tectonic and syn-tectonic *DS* in which progressive discordances were recorded. The palaeosol study established a humid–dry climate changes out of phase with *DS*. The major truncation/incision surfaces, sedimentary environment changes, and the stratigraphic architecture of *DS*, made it possible to determine 4 orders of variations in the *FIMS*, caused by the coupling effects of tectonics, volcanim and climate at four different orders of magnitude. The very high order of variation is marked by the upper incision surface of the *FIMS*, that separate the positive accommodation (21-9 My) from the bypassing since 9 My. This order is mainly attributed to tectonic subsidence and regional uplift of the orogen. A high order (~5 My) is limited by internal regional erosional unconformities that separate 3 retrogradational cycles of different SRS, alternating volcaniclastic (nov. nom.) and erosional engine SRS. The signals are chiefly in response to subsidence and regional uplift cycles at the foreland system, combining with volcanism that caused changes in the type of the SRS. The low order (~5 My) is defined by inter/syn-tectonic DS, under a climate changecorrelated with Mid Miocene Climate Optimun-, that controls the transference of sediments and pedogenesis. The very low order (~1My) is determined by the internal arrangements of DS in response to tilting pulses, episodic volcanic supply, climate, and palaeoenvironment autocyclic variations.

This multidisciplinary work allows to distinguish different environmental signals and their magnitude order that, depending on the resolution scale of the approach, could be not detected or overlooked in a framework of a basin analysis.

TO SEE OR NOT TO SEE MILANKOVITCH CYCLES – EXAMPLE OF THE LOWER DEVONIAN HEMIPELAGIC SUCCESSION FROM CZECH REPUBLIC

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High-resolution time scales are crucial to understand Earth's History in detail. Indeed, precise and accurate temporal relations are essential to link events and their causality. In that context, the Paleozoic timescale still suffers from the largest time uncertainties of the whole Phanerozoic. A better calibrated time scale would offer more insight into the mechanisms and causes of major biological evolutionary steps, adaptive radiations, mass extinctions and recoveries, as well as pattern of climate changes occurring throughout the Paleozoic. Finding good proxies for climatic cycles is essential, but diagenesis can have a strong impact on most of these proxies. In various cyclostratigraphic studies, the fit of spectral peak ratios with those of the orbital cycles, is classically used as an argument for a preserved climatic signal.

Magnetic Susceptibility (MS) is often-used in sedimentary rocks for correlations, paleo-sea level or paleo-climatic reconstructions and cyclostratigraphy, based on the link between MS and detrital input (influenced by sea level and climate). MS is a very attractive proxy parameter, because data acquisition is straightforward enabling the creation of high resolution records. However, the interpretation of MS records in terms of depositional environment can be less straightforward because MS is a convolved signal potentially mixing the desired climatic information with undesired contributions representing other geologic phenomena (during deposition or after).

The Pod Barrandovem section, from Czech Republic, recorded Pragian and Emsian (Lower Devonian) hemipelagic sediments. A complete high resolution MS record was generated and clear cyclicities are identified through spectral analysis of this MS record.

The Praha Formation spans the first 172 m of the section and magnetic hysteresis results from this Praha Formation indicate a primary magnetic susceptibility signal, mostly carried by clay minerals. Following this and according to the fit between some of these cycle spectral ratios with orbital targets, these cycles were interpreted as Milankovitch cycles, leading to propose a precise duration for the Praha Formation.

The portion of the section between 174 and 292 m corresponds to the Zlichov Formation and hysteresis results indicate a much more complicated magnetic susceptibility signal, carried by ferromagnetic minerals. This probably means that the observed cycles are not related to Milankovitch cycles, despite the occurrence of similar spectral peak ratios than the orbital targets.

OUTSTANDING LOWER DEVONIAN MILANKOVITCH CYCLICITIES EXPOSED IN THE HUDSON VALLEY, NEW YORK STATE

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Uncertainties on the ages of Devonian stage boundaries are currently in the order of several millions of years and a cyclostratigraphic approach can help to improve the Devonian time scale. In order to do so, we need good continuous records on one hand and reliable paleoclimatic proxies on the other hand. The NY Rte 199 section, from New York State near Kingston in the Hudson Valley, is a road cut outcrop, which exposes most of the Schoharie Formation. It corresponds to the upper portion of the Emsian (upper Lower Devonian, ~393 to 400 Myr), spanning an estimated duration of about 6 Myr with relatively continuous deposition. The lithology consists of carbonates with a small portion of shales, with various degrees of bioturbation (primarily Zoophycos, Planolites and Chondrites) and with colors ranging from beige white, to brown or dark grey. The quality of most of the outcrop is so remarkable that the color variations by themselves permit recognition of Milankovitch cycles, with prominent bundles of light and dark beds. One type of cycle expression is represented by a succession of about six darker beds nested between lighter beds, which is interpreted as six precession cycles in one short eccentricity cycle (precession in the Devonian was probably about 18 ky). A pilot sampling (first 5 m out of the ~40 m of the outcrop sampled every 2.5 cm and about 20 samples distributed more or less evenly along the remainder of the section) demonstrated that in this section the average magnetic susceptibility is about 6.10^{-8} m^3/kg. Hysteresis measurements provide a high field susceptibility of about ~5.10^{-8} m^3/kg and most of the hysteresis loops are straight lines, with relatively small impact of ferromagnetic grains. The correlation between the high field susceptibility and the magnetic susceptibility is high (r= 0.91), while the correlation between the ferromagnetic susceptibility and the magnetic susceptibility is much lower (r=0.17). Thus, the ferromagnetic minerals have a low impact on the total magnetic susceptibility; its variability is driven by paramagnetic clay minerals. Importantly, despite being remagnetized (throughout the Appalachians, these Paleozoic rock sequences are all remagnetized during the Variscan-Alleghanian orogeny) the magnetic susceptibility reflects depositional information. This section is thus an ideal target for cyclostratigraphic study, through direct cycle identification on the outcrop and identification of cycles through spectral analysis of the magnetic susceptibility record.

TRACE ELEMENTS CHARACTERISTICS AND SEDIMENTARY ENVIRONMENT OF LACUSTRINE SHALE, TRIASSIC CHANG 7 FORMATION, ORDOS BASIN, NW CHINA

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Fine-grained sedimentary rocks are becoming more and more important, and have become the hotspot and focus of international sedimentology research. In the heyday of the basin development of the Triassic Yanchang Formation in Ordos Basin, it has deposited a large set of dark mudstone and black shale which is the main source rock of the Yanchang Formation. According to the rock component and the texture and structure of the shale, the source rock can be divided into massive mudstone, horizontal bedding mudstone, graded bedding mudstone, microwave shale, straight lamina shale, intermittent lamina shale 6 types. The trace elements in the shale are closely related to the formation of the environment. In this paper, the characteristics of trace elements in different types of shale are analyzed to determine the differences of sedimentary environment of different types of shale.

B and Sr/Ba ratio can be used as the sensitive mark of palaeosalinity, V/V+Ni ratio can reflect the redox environment of the sedimentary water, Using the content of the Co element, the paleo-depth h can be obtained by calculating the formula of Vs=Vo×NCo/(SCo-t×TCo) and h=3.05×105/(VS1.5).

The contents of Ni, Co, Rb, Sr, Ba, V, Be, B, Mn and other trace elements in the freshly shale samples were selected in the work area. The trace elements data in 6 kinds of rock types, such as massive mudstone, horizontal bedding mudstone, graded bedding mudstone, microwave shale, straight lamina shale, intermittent lamina shale, combined with rock components, texture and structure are analysed, shows that the massive mudstone h is 10~35 m, the average content of B is 11.7×10^{-6}, the average value of Sr/Ba is 0.37, and the average value of V/V+Ni is 0.74, which mainly developed in the delta front tributary channel; The horizontal bedding mudstone h is 31~75 m, the average content of B is 20×10^{-6}, the average of Sr/ Ba is 0.38, the average of V/V+Ni is 0.74, which is mainly developed in the prodelta. The graded bedding mudstone h is 70 ~ 100 m, the average content of B is 23.8×10^{-6}, the average of Sr/Ba is 0.44, the average of V/V+Ni is 0.75, which is mainly developed in the turbidity current deposits. The microwave shale h is 87 ~ 100 m, the average content of B is 35×10^{-6}, the average of Sr/Ba is 0.44, the average of V/V+Ni is 0.75, which is mainly developed in the semi-deep lake. The straight lamina shale h is 100~120 m, the average content of B is 42.6×10^{-6}, the average of Sr/Ba is 0.47, the average of V/V+Ni is 0.78, which is mainly developed in the deep lake. The intermittent lamina shale h is 105~120 m, the average content of B is 44.7×10^{-6}, the average of Sr/Ba is 0.49, the average of V/V+Ni is 0.85, which is mainly developed in the deep lake. The results show that the sedimentary depth of the 6 types of shale sediments increases and the degree of reduction is enhanced synchronously. Affected by the delamination of water body, the salinity of the water body increased with depth.

TIMING OF SEA-LEVEL FLUCTUATIONS AND CARBON CYCLE PERTURBATION ASSOCIATED WITH THE SINEMURIAN-PLIENSBACHIAN BOUNDARY EVENT: NEW INSIGHT FROM THE HIGH ATLAS MOUNTAINS OF MOROCCO

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The Sinemurian-Pliensbachian Boundary event (SPBE) in the lower Jurassic has been studied and recognized in multiple sections throughout Europe in the last years. It is characterized by a negative carbon isotope excursion (CIE) of ~2‰ measured in both fossil carbonate and continental organic matter. Furthermore, the event is associated with a rapid transgression and a change towards less carbonate content in the sediments. However, the relation and timing of both sea level fluctuations and carbon isotope excursion are in detail imprecise.

Here we present results of three sections located in the Central High Atlas Basin of Morocco, which hosted a lively carbonate factory during the Early Jurassic. We used a combination of chemo-and biostratigraphy to date the sections and to recognize the SPBE in each of them. By looking at the lithology, sedimentary structures and microfacies, we could determine depositional environments and thus could trace detailed transgressive-regressive trends in the rock succession.

Our results show that the CIE can be recognized in every studied section. The absolute values of our organic carbon isotope curve are comparable to other sections, although the amplitude is slightly smaller (~1.5‰). Our data shows moreover, that the negative shift is preceded by a previously unknown positive shift. Furthermore, the latest Sinemurian is marked by a thick (up to 30 m) red interval in the shallow realm, which is characterized by red continental deposits featuring clay-and siltstones with calcrete. This interval is overlain by shallow marine lime-and dolostones, which mark the onset of the isotope excursion and therefore the Sinemurian-Pliensbachian Boundary. When compared to multiple sections throughout Europe the similarities regarding the negative shift and the transgression are striking. However, the pronounced sea level lowstand in the latest Sinemurian marking a forced regressive surface/interval and the positive shift preceding the CIE are major differences.

The timing of both CIE and sea level fluctuations raises questions about the causality and relationship of the two, since transgressions are usually linked to increased burial/preservation of organic matter, which would induce a positive rather than a negative one, as observed during the SPBE. So far, no hypothesis has been proposed that can fully explain this peculiar scenario, hence further research is needed to shine light onto this matter.

INTEGRATING SEQUENCE STRATIGRAPHY AND STABLE ISOTOPE GEOCHEMISTRY TO RECONSTRUCT ENVIRONMENTAL AND CLIMATE CHANGE IN THE JURASSIC SUNDANCE SEAWAY

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Epicontinental seaways are the dominant source for much of our information about ancient marine biodiversity. Even so, growing evidence suggests that these seaways were often decoupled from the open ocean because of variations in water mass, depth, salinity, and stratification. Hence, understanding these systems is critical to understanding the temporal and biogeographic influence on marine biodiversity as well as the role epicontinental seas play in terms of ocean circulation and climate change.

In the Middle–Late Jurassic (Bajocian–Oxfordian, ~170–155 Ma), western North America was covered by the Sundance Seaway, a shallow epicontinental sea that extended nearly 2000 km from southern Utah northward to its open-ocean connection in British Columbia. The Sundance Seaway had a peculiar palaeogeography, characterised by an elongated shape and the presence of a single entrance located at high latitude. Because of this shape and its north–south orientation, the Seaway was likely prone to pronounced latitudinal temperature and salinity gradients, which would have controlled patterns of faunal diversity, distribution, and immigration into the Seaway. No tests based on geochemical proxies have yet been performed to test these hypothesized temperature and salinity gradients and the connection of the Seaway water-mass with the open ocean.

In this study, we integrate results from stable isotope (carbon and oxygen) geochemistry of biogenic carbonate within a sequence stratigraphical and sedimentological framework, to reconstruct palaeoenvironmental changes in the Seaway through time. The Twin Creek, Gypsum Spring and Sundance Formations of Wyoming and southern Montana were divided into seven third-order depositional sequences. These sequences include facies associations from carbonate ramp, siliciclastic wave-dominated shelf, siliciclastic tidal coast and mixed evaporate-siliciclastic desert depositional system. Low-magnesium calcite mollusc shells of bivalves (Ostreidae and Gryphaeidae) and belemnites were collected from every marine depositional sequence, and where possible, across the onshore–offshore gradient. Preliminary results indicate that carbon isotope data are consistent with the presence of a fully marine system in offshore settings within the Sundance Seaway. Using reasonable estimates for the isotopic composition of seawater, palaeotemperatures derived from the oxygen isotopes of the belemnites range from ~17–21°C and ~ 22 to 27°C for the bivalves. These estimates indicate that the Seaway was warmer than the adjacent open ocean, and this has broad implications for how ocean-climate system may have operated. We speculate that these relatively warm waters, not only provided warmth to the adjacent continent, but also represent a potential source of warmth for higher latitudes.

EVOLUTION OF A CARBONATE-EVAPORITE-SILICICLASTIC SYSTEM IN THE DISTAL PART OF A RETROARC FORELAND BASIN: MIDDLE-LATE JURASSIC SUNDANCE SEAWAY, USA

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Well exposed Middle-Upper Jurassic (Bajocian to Oxfordian, ~170–155 Ma) strata of the Gypsum Spring and Sundance Formations in Wyoming and South Dakota, USA, allow to reconstruct the evolution of the distal portion of a retroarc-foreland basin at the transition between continental and shallow-marine deposition. The strata are organised into seven third-order depositional sequences, which preserve eighteen facies associations in carbonate ramp, siliciclastic wave-dominated shelf, siliciclastic tidal coast, and mixed evaporite-siliciclastic desert systems. Although the geographic and stratigraphic occurrence of the facies associations is initially complex, the sequence stratigraphic analysis reveals a strong organization, which allows to explain the complex and often confused lithostratigraphic history of the region. Updip–downdip variations, stacking generated by changes in the rates of accommodation and sedimentation, facies partitioning within depositional sequences, and partitioning among depositional sequences, control the geographic and stratigraphic patterns of the facies associations. The gradual change from a carbonate-evaporite system to a siliciclastic system is linked to the slow climatic shift from predominantly arid environments to winter-wet semiarid conditions through time. This shift was likely caused by the northward drift of the region out of the global subtropical arid belt coupled with the filling of the foreland basin by the prograding coastal plain. This lithologic shift may also have been aided by hypothesized global cooling during the Callovian–Oxfordian transition. The results of this study provide insight into the interplay between relative sea-level, sediment supply and climate change into the evolution of foreland basins in mixed-lithology settings.

RECENT SHORELINE CHANGE AT THE MUNI-POMADZE LAGOON, GHANA: INFLUENCES AND IMPACTS

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Lagoon-barrier systems are a dynamic coastal environment that are particularly vulnerable to sea level rise (SLR). The barrier separating a lagoon from the ocean is breached in response to local oceanic and weather conditions. Breaching creates an ephemeral connection between the lagoon and ocean causing estuarine-like conditions with significant impact on hydrology, sedimentology and ecology. Increasingly, human actions have impacted these environments with potential to increase the connectivity between the ocean and lagoon. Conversely, increased breaching at lagoons has significant impact on local populations. The Muni-Pomadze lagoon (MPL) in central Ghana is a small lagoon-barrier system that is intermittently open to the ocean. Following natural opening in spring 2014 the lagoon remained open to the ocean for more than two years. Field observation, digital mapping and GIS analysis of the shoreline has enabled an understanding of how this ocean connection has impacted coastal morphology, erosion and sedimentation. Opening has resulted in rapid changes to the location of breaching and erosion on the barrier as well as sedimentation in the lagoon. Projections for SLR at MPL indicate increasing connectivity thus an understanding of changes associated with long term breaching can help to understand the impacts of SLR. Increasing lagoon-ocean connectivity has implications for local resources and ecosystem services that underpin the livelihood and wellbeing of local subsistence communities. In Ghana, coastal management tends to be ad-hoc and populations dependent on dynamic lagoon environments have relied on indigenous customs that may no longer be relevant. Elucidating links between sea level rise, lagoon-ocean connectivity, changes to the coastal environment and local practices is important to managing lagoons not only in Ghana but across coastal West Africa.

THE LATE DEVENSIAN GLACIATION ON THE WEST SHETLAND MARGIN: POSSIBLE PITFALLS IN A SEQUENCE STRATIGRAPHIC APPROACH TO INTERPRETATION

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The Late Devensian of the West Shetland margin of the UK forms a good example of a temperate latitude glacigenic margin. Analysis of seismic and sedimentological data allows a comparison to be made with a theoretical non-glacigenic margin in a sequence stratigraphic context.

In a conventional, non-glacigenic setting, a falling sea-level causes exposure of some or all of the continental shelf. This is accompanied by re-working and erosion of the exposed marine sediments and the incision and advance of fluvial systems across the shelf. At the ensuing low stand, coarse clastic sediment is delivered to the outer shelf or the shelf edge and slope. As sea-level rises following the low stand, the coarse clastic systems retreat with the migrating coastline in a series of backstepping systems. The outer shelf and slope is starved of coarse sediment.

In the West Shetland example, the falling stage of the sea-level is represented by the widespread glacigenic unconformity which has removed any evidence of the early stages of sea level fall which may have been present on the inner shelf. The low stand sea-level is interpreted as being equivalent to the LGM, which is theoretically true of all temperate glacial-marine systems. At this point, the ice reached the shelf edge and delivered large volumes of clastic sediment to the shelf edge and upper slope, possibly in a comparable way to the non-glacigenic model.

With the onset of deglaciation, the West Shetland ice retreated across the shelf, forming a complex series of backstepping grounding line systems which stretch for more than 45 km to the inner shelf, with only fine suspended sediment (ignoring for the moment IRD) being delivered to the outer shelf. In this respect, it resembles the non-glacigenic model.

However, this is where the Shetland example diverges from the non-glacigenic model. As deglaciation progressed, the increased buoyancy provided by the accompanying sea-level rise, caused a major ice re-advance of more than 30 km, stripping much of the sediment from the inner shelf and delivering it to the mid and outer shelf. The formation of a large wedge of coarse clastic sediment in a non-glacigenic setting would normally be associated with a sea-level fall, but in the Shetland glacigenic example, it is the product of sea-level rise. After the initial re-advance, there followed a series of similar, smaller scale events during the overall retreat. The accumulation of significant thicknesses of stratified sediment indicates sea-level rise was still active throughout deposition of this sequence.

The West Shetland example shows how, if taken out of context, it would be possible to misinterpret a coarse clastic wedge in a glacigenic sequence as the result of sea-level fall and not of sea-level rise. This has important implications for interpretation of ancient glacigenic sequences in the rock record.

INVESTIGATIONS OF A HIGH LATITUDE SUBMARINE CHANNEL SYSTEM IN THE LOFOTEN BASIN, POLAR NORTH ATLANTIC

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The Norwegian margin of the Polar North Atlantic comprises the Lofoten Basin Channel. This channel system connects upslope with the Andoya Canyon which is the only canyon to cut back across the continental shelf in this region. Multibeam swath bathymetric data and side-scan sonar data allows the identification of the Lofoten channel described by e.g. Cofaigh et al. (2006). A 5.4 m sedimentary core was collected by the Calypso coreer during the mission SHOM MOCOSED 2014 on the Pourquoi Pas ?

A stratigraphic study was realised by comparing several parameters: the magnetic susceptibility and IRD concentration, with six reference cores: JR51-GC03, JR51-GC05, JR51-GC06, GS134-01, GS134-02, and GS134-03, near the study area. Then sedimentary analyzes (rX imaging, XRF ratio microgranulometry) and micropaleontological were compared to determine sedimentary facies. CHIRP seismic profiles were also interpreted.

Those datasets show the influence of turbidity currents in the sedimentation on distal levees of the Lofoten channel and confirms the low activity of turbidity currents since the Holocene. The core, which is 3 km away from the channel, witnesses only the biggest turbidity currents which have occured while the last 50 ka ^{14}C BP, and at least the record of three turbidites since 9 ka cal ^{14}C BP.

THE FATE OF TRAVERTINE FABRICS – CASE STUDY OF EARLY DIAGENESIS IN THE Y-10 CORE (MAMMOTH HOT SPRINGS, YELLOWSTONE, USA)

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The Y-10 core, drilled in 1967 by the USGS to obtain data on downhole water chemistry and temperature in the northern part of Yellowstone National Park (Wyoming-Montana, USA), shows a 113 m long record of hot spring carbonate deposition at Mammoth Hot Springs (0 – 53 m) covering Mesozoic sediments. Today it offers a unique view into the history of travertine deposition and the rapid, early diagenesis within a still active hot spring system. The Holocene-Pleistocene travertine sequence of the Y-10 core, in combination with observations from active, Recent deposits within hot springs at the surface, offers a unique opportunity to investigate how $CaCO_3$ (calcite and aragonite) crystal textures, their pore structure and stable isotope geochemistry become rapidly transformed.

Low-to high-resolution petrographic observations of recent travertine in Apron-Channel, Proximal Slope and Pond Facies shows how short episodes (days, weeks) of flow or water chemistry changes can already kick off neomorphic replacement processes before precipitation retakes again. Within the Y-10 core section, the top part (0 – 6 m) is particularly indured as a result of meteoric dissolution and cementation.

Diagenesis between 6 and 53 m is dominated by neomorphism resulting in equant, anhedral calcite mosaics with microporous, dark brown-greyish crystal cores and cementation of interparticular and interlaminae pore spaces with micritic to euhedral, equant calcite crystals that are well-zoned under cathodoluminescence. The overall result neomorphism and cementation is a tendency for erasing and homogenizing initial, fine and delicate aragonite needle textures that built elongated or radial shrubs, formed stacked laminae or that encrusted microbial filaments. The textural link with the original, aragonitic needles is only locally preserved.

Stable carbon and oxygen isotope results, both bulk analyses and spot or detailed cement transect analyses using micro-SIMS (University of Lausanne, SWISS SIMS), suggest that the fluids responsible have been isotopically similar to the hot spring fluids today, a minor offset is created during recrystallization and cementation by meteoric waters especially in the top 6 m, but more pristine signatures and trends can occasionally still be recorded when examining the neomorphosed aragonite – now calcite – core of crystals at several depth levels within the Y-10 core. Early diagenesis in the Y-10 core is mostly constructive and resulted in pervasive, aggrading neomorphism and circumgranular or pore-filling cements. Neomorphism created isolated microporosity within $CaCO_3$ crystals, but the combination of processes reduced the total pore space by 30 – 40%, as calculated from reconstructed 3D micro-computed tomography images. When comparing these results with previous literature and datings, the extent and impact of early diagenesis on reshaping the fabric and geochemical signals has been underestimated.

UNCONFORMITYBOUNDED PALEOFLORAS IN THE CARBONIFEROUS-PERMIAN TRANSITION AT THE HENAREJOS BASIN, SE IBERIAN RANGES (SPAIN)

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The precise definition of the Carboniferous-Permian boundary based on paleoflora in Western Europe is still controversial. The kind of flora in the continental basins is influenced by its paleolatitudinal location, but it is also climatically controlled and, therefore, its biostratigraphic range is not accurate. As an example, in the Autun Basin, South France, a vertical alternation between grey strata with Stephanian B-C (Carboniferous) macrofloras and red rocks with Autunian (Permian) macrofloras has been described. The coeval existence of late Carboniferous and early Permian floras was explained as an alternation of hygrophyte and xerophyte associations, which were climatically controlled.

In the SE Iberian Ranges, the Minas de Henarejos anticline is a key location to analyze the Carboniferous-Permian transition and its relation with the end of the Variscan compressive deformation and the onset of Mesozoic extension. Recent coal mining works have exposed high quality outcrops, which allowed a new detailed stratigraphic study, with a thorough identification of unconformities, and the characterization of the tectonic activity affecting the region.

The outcroping stratigraphic formations begin with Silurian quartzites and shales. Unconformably, there is a Stephanian B-C grey succession of siltstones, sandstones, conglomerates, breccias, and coal levels, here described as the Minas unit. A new unconformity separates those facies from the overlying unit, composed by white conglomerates with undifferentiated macroflora remains. Another clear unconformity separates the white conglomerates unit from a thick succession of red conglomerates and fluviatile rocks of middle-late Permian age. The uppermost formations are constituted by Triassic rocks in the classic germanic facies.

All those formations draw a regional NNW-SSE anticline structure related to the Alpine orogeny with the Silurian in the core and the Triassic in the limbs. Nevertheless, the Paleozoic outcropping formations are affected by compressional and extensional structures resulting from a complex interaction between different Variscan and Alpine phases of deformation. The Stephanian B-C Minas unit is affected by WNWESE thrusts, reverse faults and folds. These compressional structures do not cross the white conglomerate unit. Moreover, the deposition of the Permian alluvial units was controlled by a N120° extensional tectonic regime, as demonstrated by the presence of syn-sedimentary accommodation faults. These faults are even affecting the previous compressive structures.

Although the Autun Basin shows a coexistence of hygrophyte and xerophyte floras in the Carboniferous Permian transition, this does not happen in the SE Iberian Ranges, as each paleoflora is separated by unconformities and different tectonic settings. Moreover, when the Minas unit occurs over any of the conglomerate units, this is due to the reverse faults and thrusts of the Alpine compressional phase. New paleontological or other kind of evidences should be required in order to solve the uncertainties of the Carboniferous-Permian Boundary in Western Europe, but the combination of new stratigraphic and tectonic detailed studies in other basins could be an important tool to do so.

FIELD INSIGHTS INTO THE LATE MIOCENE FLUVIO-DELTAIC BALTA FM OF THE EAST CARPATHIAN FORELAND BASIN

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The NW Black Sea contains the basin's largest clastic system. Sediment supply to this system is currently dominated by the Danube River (95%) that delivers 90 MT of sediment per year. However, sediment supply started in the Late Miocene, when the Danube was still filling the upstream Pannonian Basin. The search for an alternative supply system sparked our interest in the stratigraphy of the Carpathian Foreland Basin in the border region of Romania, Moldova and Ukraine. Subsequent field research has highlighted the significance of the Balta Fm whose sediments represent a largely underappreciated, and frequently overlooked clastic system. Sedimentary facies analysis of the Balta Fm was integrated with a review of published local literature, micropalaeontological results and historical borehole information. The formation is ~300 km wide, up to 350 m thick and rapidly pinches out from the foredeep towards the platform. Its lowermost part is clay dominated and consists of subordinate delta front sand bodies interspersed between muds. The middle unit contains separate delta plain channels (generally 5-10 m thick) or channel belts encased in pro-delta, interdistributary bay and floodplain muds. These are overlain by a unit with amalgamated delta plain channel deposits with only minor amounts of associated mud. The abundance of upper flow regime sedimentary structures in channel sands, the absence of peats (or coals) and the presence of calcareous nodules suggest a strongly seasonal and relatively dry climate with a flashy discharge regime. The Balta Fm offers an excellent example of a largely prograding fluvio-deltaic system that came into being due to a high sediment flux from the uplifted Carpathians and was accommodated in a broad foreland basin. Amalgamation of channel bodies in the upper part of the Balta Fm during the Late Miocene was followed by deposition of more localised incised valley fills during the Pliocene and Pleistocene, which was accompanied by the formation of prominent soils in the intervening areas. This development suggests a progressive decrease in accommodation space in the foreland due to continental collision in the Carpathians.

OBLIQUITY-PACING OF THE LATE DEVONIAN MASS EXTINCTION EVENT

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The Late Devonian envelops one of Earth's "Big Five" mass extinction events at the Frasnian Famennian boundary (374Ma). Environmental change across the extinction severely affected Devonian reefbuilders, besides many other forms of marine life. Despite the biosphere shake-up, cause-and-effect chains leading to extinction remain poorly constrained. This gap in understanding primarily exists because the Late Devonian stratigraphy is poorly resolved, compared to younger extinction events. Here, we apply a cyclostratigraphic approach to attain insights into the pacing of paleoenvironmental change across the Devonian globe at unprecedented resolution. Specifically, we present the first global orbitally-controled chronology across this multifaceted interval. Our timescale stipulates that 600 kyr seperate the lower and upper Kellwasser positive excursions. The latter excursion is paced by obliquity, and is therein similar to Cretaceous Ocean-Anoxic-Event-2 (OAE-2). The obliquity imprint suggests polar amplification of Kellwasser-related cooling, as well as its coincidence with a 2.4-Myr node in eccentricity.

SEDIMENTOLOGICAL AND CHEMICAL MARKERS OF EARLY HUMAN INDUSTRIES AND CLIMATE SHIFTS IN PERSEPOLIS (SW IRAN) DURING THE HOLOCENE

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The Persepolis basin (SW Iran) in the Zagros Mountains is under the influence of several climate regimes including Atlantic-Mediterranean Westerlies, the Siberian Anticyclonic currents and the Indian Summer Monsoon (IOSM). Latitudinal drifts of the Intertropical Convergence Zone (ICTZ) control the relative influence from each of these regimes from which Persepolis climate ultimately results. Paleoclimate records are missing from this mid-latitudinal mountain site that has been shaped by Human societies since at least the Achemenids, 2500 years ago. Here we investigate both paleoclimate and anthropogenic markers within peatbog sediments from a 13 kyr cal. BP core collected a few miles from the ancient Achemenid city of Persepolis (29°54'50"N, 53°05'27"E). Grain size and organic matter content of the peat allow to distinguish three main sedimentological units including a (A) fine silt-dominated facies with low Organic Matter (OM) content (4-12%) and many coarse silts aeolian quartz at the bottom of the studied section (500-600 cm, 11-12 kyr cal. BP), (B) a medium silt facies with a larger OM content (11-15% with a 22% spike at 420 cm, i.e. 9 kyr cal. BP) between 370 and 500 cm (7.0-11 kyr cal. BP) and (C) a mixed coarse to medium silts and fine sand facies rich in shiny-type Quartz grains with larger OM content and variability (13-26%) followed by less aeolian quartz at 185-370 cm (1.8-7.0 kyr cal. BP). Crustal elements (Al, Sc, Th) display almost similar patterns with general decreased concentrations from unit A (bottom) to C (top). Two clear spikes are identified both for the silt fraction, MO and crustal elements at 530-600 cm (11.8-12 ky cal. BP) and 420-440 cm (8.9-9.3 kyr cal. BP) in units A and B. We associate the deeper spike with the maxirmum Younger Dryas (YD) event. The three identified units likely correspond to dry (unit A and B) and more humid (with more hydrodynamics features) (unit C) periods. Lead (Pb and Strontium (Sr) isotopes are consistent with these trends. Sr isotope ratios ($^{87}Sr/^{86}Sr$) allow to discriminate three end-members including (i) a highly radiogenic imprint in unit A that confirm a strong crustal input, (ii) less radiogenic ratios in unit B that correspond to a more local carbonate end-member and (iii) a marine imprint in the top of unit C suggesting sea-spray contribution. Pb isotopes ($^{206}Pb/^{207}Pb$) allow to discriminating anthropogenic imprints in the top sequence (C) where Pb and Copper (Cu) are enriched since 5 kyr cal. BP. Here we infer that either Omani, Turkish and/or Cypriot Cu ores may have contributed to Cu encountered in this anthropogenic sequence. The combination of sedimentological and chemical (trace elements and isotopes) markers provides insights on the paleoclimatology and early industrial imprints that contribute to the paleoenvironmental reconstruction of Persepolis region.

MID TO LATE MIOCENE UPLIFT AND DOMING OF MADAGASCAR: CONSTRAINTS FROM TOPOGRAPHY, CENOZOIC STRATIGRAPHY AND PALEOGEOGRAPHY

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Madagascar is an Archean to Neoproterozoic continental crust surrounded by transform, oblique and divergent margins: the oblique Morondava Basin to the west, pounded by the Davie Fracture Zone, and to the north, the divergent Mahajanga (Majunga) Basin connected to the Somali Oceanic Basin. This 1600 km long island is a high axial plateau with elevations from 1200 to 1800 m. The top of the plateau corresponds to weathered planation surfaces (etchplains), bounded by more or less high scarps.

We here present geological arguments for the age and the timing of the Madagascar Plateau. This analysis is based on a double, coupled analysis of the onshore geomorphology (stepped planation surfaces) and the offshore margin stratigraphy (seismic stratigraphy, and paleogeography). The geomorphological analysis is based on a characterization, mapping and dating of stepped planation surfaces (mantled to stripped etchplains, pediments and pediplains). The dating is based on their geometrical relationships with dated magmatic rocks and sediments. The difference of elevation between two planation surfaces (corresponding to local base level) provides a proxy of the uplift. The sequence stratigraphic analysis is based on a biostratigraphic reevaluation of 4 industrial wells (foraminifers and nannofossils on cuttings) and the interpretation of several industrial and academic seimic datasets.

Uplift periods are characterized by (1) seaward tilting of the margins overlain by planar, onlapping reflectors, (2) forced regression wedges and (3) stepping planation surfaces.

(1) During Paleocene to Early Miocene times (66 to16 Ma), Madagascar is a quite flat low elevation domain with remnants of an oldest pre-Madagascar Trap (90 Ma) surface. This low relief is highly weathered with growth of numerous lateritic profiles and surrounded by large carbonate platforms with very few siliciclastic sands influx.

(2) Late Miocene is the uplift paroxysm with (i) margin tilting (Morondava), (ii) increase of siliciclastic sand flux since middle Miocene and (iii) major stepping of dated planation surfaces.

(3) This result in a convex up shape pattern for the weathered upper Cretaceous surface, giving the island its present-day dome morphology (with a central plateau).

(4) Uplift amplitude can be estimated based on present-day elevation of Paleocene to Eocene marine sediments located 100 km north-east of Toliara and now at an elevation of 900 m. If the absolute sea level was around 50-100 m above present-day sea level during Late Eocene times, this means a surface uplift of around 800-850 m.

(5) Uplift mechanism has to explain a very long wavelength deformation (x1000 km) necessary due to mantle dynamics. Relationships with other East African domes (Ethiopia, East Africa, South Africa) are discussed.

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PAIRED ELECTRON SPIN RESONANCE AND IN SITU PRODUCED TERRESTRIAL COSMOGENIC NUCLIDE AGES ON A PLEISTOCENE FLUVIAL SEQUENCE OF THE TÊT RIVER, EASTERN PYRENEES (FRANCE): IMPLICATIONS FOR QUATERNARY CRUSTAL UPLIFT REGIMES

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Sequences of alluvial strath-and fill-terraces record the long-term variation of fluvial transport regimes in response to Quaternary climatic changes. These landforms are also useful tools for quantifying river incision rates and inferring vertical uplift of the Earth's crust. Age constraints on Pleistocene fluvial sequences also provide a potential for correlation with climatic controls on catchment sediment delivery. Land cover, precipitation intensity, and permafrost play key roles in catchment-scale sediment supply to river channels, and the major aggradational and incisional phases tend to occur in step with global 100 ka orbital cycles. It has also been established that incision phases occur during periods of climatic transition whereas aggradation coincides with periods of fluvial dynamic equilibrium. This evidence is mainly based on dated Pleistocene fluvial sequences in periglacial environments, i.e. in non-glaciated catchments characterized by the presence of continuous permafrost. Recent studies of North-Pyrenean glaciofluvial terraces have shown similar trends, but with cycles of aggradation and incision occurring in response to major stages of mountainside colonization by woodland vegetation belts rather than to the beat of advancing and retreating outlet glaciers. Pyrenean fluvial sequences have benefited from systematic mapping on both sides of the Pyrenean range, but the chronostratigraphy of these deposits is still largely based on relative criteria such as terrace staircase geometry and contrasts in clast weathering intensities or in soil types capping different generations of terrace treads. Published ages have nonetheless been obtained from OSL and in situ produced Terrestrial Cosmogenic Nuclide (TCN) vertical profiles on both sides of the range (Gallego, Cinca and Sègre rivers on the south side, and Ariège, Garonne, Neste, and Aspe on the north). Here we document the River Têt catchment (1400 km^2), which extends from the Pyrenean Axial Zone directly to the Mediterranean Sea via a succession of mid-to late Cenozoic intramontane sedimentary basins. Five generations of alluvial terrace were identified in the catchment based on clast weathering intensities and soil profile characteristics, and eight levels can be distinguished based on terrace staircase geometry. We present two age series obtained from ESR and TCN vertical profiles on the Têt terrace staircase. Modeled ages did not allow clear correlations between terrace level formation and marine isotope stages. Unlike data previously produced for the Ariège catchment, it was likewise not possible to construct a well-defined soil chrono-sequence, i.e. clear correlations between the age of a tread level and the duration required to produce its distinctive soil cover. However, the ages obtained were sufficiently robust to quantify the magnitude of Pleistocene incision of the landscape by the Têt River. On that basis, we infer the longitudinal variability of vertical crustal uplift between the Pyrenean Axial Zone, the foothills and the coastal plain.

SURFACE EXPOSURE DATING OF LATEGLACIAL ICE FLUCTUATIONS IN THE UPPER ARIÈGE CATCHMENT (FRANCE): INFERENCES CONCERNING PALEOCLIMATE AND IMPLICATIONS FOR UPPER PALEOLITHIC HUMAN DISPERSALS THROUGH THE PYRENEES

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A growing body of research has been focusing on the extent and chronology of Pleistocene glaciation in the Pyrenees. The chronology of the last deglaciation still remains poorly constrained because studies published until now have mainly dealt with terminal moraine systems and much less with till deposits located farther up-valley and in the cirques. This is the case in the Ariège valley, for example, where MIS 4 to Global LGM glacier fluctuations are well identified whereas Lateglacial and Holocene ice extents are still poorly known. Filling the current knowledge gap about post-LGM glacier fluctuations in the Pyrenees should provide constraints for refining a range of paleoclimatic, geomorphological, and paleoanthropological evidence relevant to Quaternary science: (i) establishing altitudinal fluctuations of the paleo-ELA can be used as a paleoclimatological proxy for approximating the variability of summer paleotemperatures and winter paleoprecipitation based on transfer functions such as degree-day models. (ii) Inferring catchmentwide glacial and paraglacial erosion rates based on the quantification of well-dated sedimentary deposits produced at the time of the last Termination can be extrapolated to estimate catchment-wide denudation rates at previous Pleistocene glacial terminations. (iii) Documenting the establishment of ice-free mountain passes connecting the two sides of the Pyrenean range contributes to reconstructing paleolandscapes at the time when Magdalenian and Azilian hunter-gatherers began to populate the Pyrenees. Here we focus on the upper part of the Ariège valley and the Col du Puymorens area, where well-preserved ice-marginal deposits such as frontal and lateral moraines, but also ice-marginal paleolacustrine deposits, were mapped and ranked chronologically within a sequence of three glacial stades recorded by three composite glaciers respectively 20, 15 and 9 km long. The corresponding ELAs stood around 1800, 1950 and 2175 m a.s.l. We find that the Col de Puymorens (1800 m a.s.l.) became free of ice between stades 1 and 2. Surface exposure dating of boulders embedded in moraine ridges allow us to ascribe the two most extensive ice extents to the Oldest Dryas, and the smaller one to the Younger Dryas, i.e. ~17.5–18 ka for the 20 km composite glacier and ~15.5–16 ka for the 15 km glacier. A comparison of these results with other data acquired in the Bassiès massif, in the Upper Vicdessos catchment, and in the Upper Têt catchment farther east (Carlit massif) highlights the variability of Lateglacial ice extents, with the sharpest contrasts between the northern side of the range, i.e. under wetter and colder climatic conditions (Atlantic weather systems), and its southern side exposed to warmer and drier Mediterranean climates.

ROLLING REEFS IN THE LATE DEVONIAN OF BELGIUM

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The upper member of the Aisemont Formation (Upper Frasnian, S Belgium) yielded a surprisingly diverse assemblage of macroids varing in size, shape and composition, from simplest microbial oncoid to complex, polytaxic circumrotatory macroid. Besides simple oncoids dominated by either by microbial coating or skeletal organisms (e.g. bryozoan), occur composite oncoids that involve both skeletal and microbial organisms. However, polytaxic circumrotatory (free-rolling) macroids, produced by diverse organisms, usually in sequential coating formed small (up to 12 cm in diameter) rolling reefs. The later occasionally became immobile and grew as small coverstone reefs. The dominant (in frequency and volume) encrusting organisms are the tabulate corals and stromatoporoids that both possesed the ability to cement themselve to the substrate. Microbes also contributed to the formation of macroids though the volume they occupy is relativelly low. Geopetal sediment filling of cavities displays various directions indicating the rolling of the objects during their formations. Annual rolling or tilting may be related to seasonal storms. Skeletal invertebrates simingly grew during the good season and partly or totaly died and was colonized by microbes during the bad season. The surface of the macroid was subsequently re-colonized by skeletal organisms at the good season when suitable conditions resettled. Estimating the age of these object has been attempted by counting the number of successive generations of encrusting organisms and growth bands within colonies. Circumrotatory macroids were in average 8 years old but some reached 12 years. Domal objects were more stable and durable as some lived up to 30 years. Despite environmental conditions seemingly suitable for reef development, no large scale reef setteled during the time of deposition of the upper member of the Aisemont Formation. This lack seems to be related to the progressive degradation of the environment due to the ongoing Late Frasnian biocrises (Kellwasser events).

INAND OUT-OF-SEQUENCE EVENT STRATIGRAPHY ACROSS THE DEVONIAN–CARBONIFEROUS BOUNDARY – A VIEW FROM THE SHELF IN S BELGIUM

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The Devonian-Carboniferous Boundary (DCB) is known to be associated with one of the 'Big Five' extinctions of the Phanerozoic. It was also a time marked by a rapid change in deposition called Hangenberg event. In pelagic sections, the succession displays (1) an anoxic black shale unit (Hangenberg Black Shale HBS) recording the main extinction phase, (2) the Hangenberg Shale (HS), not anoxic, (3) the Hangenberg Sandstone (HSS), and (4) the Stockum Limestone (SL). The succession was interpreted as a transgressive pulse (HBS) followed by a rapid regression (HSS) and by the return to normal conditions of deposition. Consequently, the HSS was regarded as a sequence boundary. In Belgium, the DCB transition is well exposed in shelf settings and the HBS-SL interval corresponds to c.25 m of mixed carbonate-siliciclastic deposits, whereas in the French and German pelagic sections, the events are condensed in a c.4 m-thick succession. Events are thus best developed and separated in the Belgian neritic sections than in pelagic ones where they appear superimposed to each other. The latest Devonian Comblain-au-Pont Fm recorded a 3rd-order transgression that produced a switch from coastal siliciclastic to proximal carbonate-siliciclastic deposits with an increase of the carbonate content. This trend continues up to the lower member of the Hastière Fm (lowermost Tournaisian). Hence the Comblain-au-Pont and lower Hastière formations are regarded as the TST. The HST corresponds to the massive crinoidal rudstones of the middle member of Hastière Fm. The latter is capped by an erosion surface that is interpreted as the 3rd-order sequence boundary. The next sequence starts with the upper member of the Hastière Fm which is typically made of thin-bedded subnodular and crinoidal packstone. It grades into shale with the Pont d'Arcole Fm that recorded the maximum flooding zone of the sequence. Superimposed to the 3rd-order sequences are particularly well marked orbitally-forced precession cycles of c. 18.6 ka, appearing as regular c. 40 cm-thick couplets of limestone/calcareous shale beds. These couplets are interpreted as cycles deposited during alternations of dry periods (limestone) and wet periods (shale). The HBS event is variously developed in thickness and is sometimes not marked on shallow platforms. This local absence has often been interpreted as a stratigraphic gap. It is however more likely that the anoxic facies were triggered by a transgressive pulse that locally did not spread into shallow-water environments where carbonate facies rich in benthic fossils continued to develop. The HSS event, recorded as a sandstone bed in pelagic sections, is variously recorded at the base of the Hastière Fm in S. Belgium, either as a bioturbaded sandy siltstone bed in proximal sections, or as a horizon with limestone clasts and reworked fossils in more distal ones. This event was responsible for the final demise of the Late Devonian faunas. The HSS occurs sharply in the stratigraphic record and does not correspond to the long sea-level fall of a 3rd-order sequence boundary, but most probably to a short out-of-sequence event. After this short-lasting regressive phase, 'normal' settings returned with the deposition of the Hastière Fm.

MORPHOLOGY, STRUCTURE, COMPOSITION AND BUILD-UP PROCESSES OF THE ACTIVE CHANNEL-MOUTH LOBE COMPLEX OF THE CONGO DEEP-SEA FAN

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The detailed structure and composition of turbiditic channel-mouth lobes is still largely unknown because they commonly lie at abyssal water depths, are very thin. The morphology, structure and composition of the Congo turbiditic channel-mouth lobe complex (90x40 km; 2525 km^2) were investigated with hull-mounted swath bathymetry, air gun seismic, 3.5 kHz sub-bottom profiler, sediment piston cores but also with Remote Operating Vehicle (ROV) high-resolution multibeam bathymetry and video. The lobe complex lies 760 km off the Congo River mouth in the Angola abyssal plain between 4740 and 5030 m deep. One important characteristic is that the lobe complex is still active and is fed by turbidity currents that deposit several centimetres of sediment per year. The lobe complex is subdivided into five lobes that have prograded by successive bifurcations of the feeding channel. The lobes are dominantly muddy. Sand represents ca. 13% of the deposits and is restricted to the feeding channel and the distributaries. The overall lobe body is composed of muddy to silty turbidites. The whole lobe complex is characterised by in situ mass wasting (slumps, debrites). The 1-m-resolution bathymetry shows pervasive sliding and block avalanches on the levees along the feeding channel and the channel mouth indicating that sliding occurs early and continuously during lobe building. The development of a new lobe is probably triggered when the gradient in the distributaries at the top of a lobe becomes flat and when turbidity currents find their way on the higher gradient of the lobe side. It may also be triggered by mass wasting on the lobe side. The abandoned lobes continue to collect important turbiditic deposits from the feeding channel spillover, so that the whole lobe complex remains active. It is noteworthy that the Congo lobe complex shares many common points regarding dimensions, sedimentation rates and mass wasting processes with muddy shallow water subaqueous deltas. This study shows that highresolution bathymetry ROV observations are needed to fully understand the build-up processes of modern channel-mouth lobes.

IN SITU RECENT AND PERVASIVE MASS WASTING AT THE ACTIVE CHANNEL-MOUTH LOBE COMPLEX OF THE CONGO DEEP-SEA FAN: INSIGHTS FROM ROV MULTIBEAM AND VIDEO SURVEYS AND FROM PORE WATER GEOCHEMISTRY

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Deep turbidite channel-mouth lobes develop by the deposition of sediments transported by gravity flows over long distances. Several studies have shown they can have complex structure and composition that are controlled by small scale channelization and sediment segregation processes. They commonly comprise debris-flow deposits whose origin remains speculative but could result from a long transport distance in association with turbidity current processes. Investigations of the Congo channel-mouth lobe complex with ROV multibeam and video, sediment cores show that mass wasting morphologies and deposits occur nearly everywhere over the lobe complex. Headscars and blocky morphologies are commonly found inside and along the feeding channel but also at the lobes rim. Morphological evidence of small-scale plastic deformation is also found in the channel mouth where the most recent lobe is currently developing. Sediment cores show a wide range of mass-transport deposits lithofacies such as slightly fractured cohesive muddy turbidites with sand injections, sandy and muddy debrites or slightly folded low cohesion muddy turbidites. A sediment core collected at the rim of the most recent lobe has sampled the whole thickness of the lobe (20 m) and shows a very complex succession of mass wasting deposits. Sediment pore water geochemistry shows a disruption in sulfate concentration profile in relation with methane migration after the mass wasting event. Curve fitting indicates that the mass wasting has occurred around a century ago. Since the lobe complex is still active and is fed by turbidity currents that have deposited several centimetres of sediment per year, mass wasting is interpreted as a consequence of ultra-high accumulation rates, over-steepening and erosion and is therefore an ongoing intrinsic process of lobe building.

MULTISCALE CHARACTERIZATION OF A MICROBIALITE-RICH MARGINAL LACUSTRINE SYSTEM: THE ATLANTIC PRE-SALT OUTCROP ANALOGUE OF THE GREEN RIVER FORMATION (EOCENE, USA)

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Subsalt reservoirs are difficult to image, both in terms of physical properties, geophysical signature and facies distributions. Reservoir outcrop analogues are commonly used to characterize reservoir architectures (including facies and heterogeneity distributions). Outcrop analogues play a key role in improving our understanding of subsurface subsalt reservoir architectures, which is of primary importance for both oil and gas exploration and production. They provide invaluable information to better understand and constrain reservoir architectures and facies heterogeneity distribution at field scale.

Sedimentology and geophysical approaches make it possible to assess the physical reservoir properties and to evaluate the parameters required to build accurate reservoir models. However, occurrence of heterogeneity at many embedded scales in these subsalt reservoirs makes the definition of upscaling rules very challenging to obtain a relevant reservoir model that can be inputted into a flow simulator.

The Laney Member of the Green River Fm. corresponds to marginal lacustrine carbonates (Wyoming, USA), and is considered as one of the most valuable analogue of the South Atlantic carbonates outcropping system. It includes a large variety of facies such as insect-microbial build-ups, tufas, coquinas, skeletal and oolithic grainstones, and silty marls. In terms of architecture, this interval is organized in patches of reef-like morphologies made up of insect microbial build-ups, with breccia and shales in between.

The internal architecture of the microbialite build-ups is really complex, with various nested scales of heterogeneities. To deal with this issue, we build an integrated study workflow based on geophysical data sedimentological acquisition. Three scales are investigated: the decametric field one, the metric outcrop one and the centimetric laboratory one. On the field, we carry out refraction-seismic survey to provide P-wave and S-wave velocities along 1D and 2D profiles. On the outcrop, sedimentological logs are precisely described. Based on this description, we perform vertical measurements of spectral gamma ray and P-wave and S-wave sonics each 20 centimeters along the outcrop. In terms of scale, these dataset is comparable to well log data. Finally, samples are extracted from the outcrop and measurements are performed in the lab: petrophysical data (porosity, permeability) and ultrasonic velocities.

Finally, the complete dataset we acquired allows us to rely subsurface and outcrop scale to the reservoir scale taking into account the different scales of heterogeneities. This workflow based on exhaustive geophysical and sedimentological data and on an integrated interpretation is a powerful tool to understand seismic and log issues at the reservoir scale in such geological complex.

DYNAMIC OF A LACUSTRINE SYSTEM IN A RIFT BASIN: EXAMPLE OF THE YACORAITE FORMATION, SALTA BASIN, ARGENTINA

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The architecture of Lacustrine systems is the result of the complex interaction between tectonic, climate, and environmental parameters, and constitute the main forcing parameters on the lake dynamic. Field analogue studies have been performed to better assess those interactions, and their impact on the facies distribution and the stratigraphic architecture of lacustrine systems.

The Yacoraite Fm. (Late Cretaceous/Early Paleocene) was deposited during the sag phase of the Salta rift basin in Argentina, is exposed in extended world-class outcrops, and permitted to study the dynamic of this lacustrine system through the facies analysis and the stratigraphic architecture evolution through time.

At the basin scale, the Yacoraite Fm. is organized in a silici-clastic dominated margin to the West, and a carbonate dominated margin to the East. Within the Yacoraite Fm., 9 system tracts have been defined based on the main surfaces and the overall facies association stacking and distribution: three Lowstand-like system tracts, three Lowstand-or Transgressive-like system tracts and three Highstandlike system tracts. The Yacoraite Fm recorded an overall transgressive trend up to the maximum of backstep of the depositional systems followed up by a prograding, filling up trend. The Yacoraite Fm can be subdivided into four main sequences. Assuming a 4 Myr duration, these sequences can then be considered as “third-order” sequences organized within a “second-order” sequence.

The four main sequences have been defined from base to top from (1) a major sequence boundary (SB) characterized by a major basinward shift of the depositional system with common exposure (even in the central part of the basin), (2) an aggrading trend of shallow depositional system, mainly preserved in the basin axis (LST-like), (3) a transgressive trend characterized by a backstep of the depositional system and an overall increase in the bathymetry in the central part of the basin (TSTlike), (4) a maximum flooding surface (MFS) characterized by a major backstep of the depositional system and the maximum of extension of the “deepest” facies association, and finally (5) a prograding/aggrading trend characterized by a basinward shift of the depositional system and a decrease in the bathymetry (HST-like).

The depositional profiles and system tracts previously identified have then been grouped into two end-members at basin scale: (1) a balanced “perennial” depositional system for the lower part of the Yacoraite Fm, and (2) a fluctuating “ephemeral” depositional system for the upper part of the Yacoraite Fm. The stratigraphic architecture of the Yacoraite Fm clearly indicates a change within the sedimentary dynamics of the basin, with a lower part characterized by a relatively stable body of water (high energy shore deposits, no clear evidence of full desiccation of the basin) and an upper part characterized by a highly fluctuating body of water (numerous evidences of full desiccation of the basin, relatively low energy shore).

STRATIGRAPHIC ARCHITECTURE AND SPATIAL DISTRIBUTION CONTROLLING FACTORS OF COAL AND CARBONACEOUS SHALES DEPOSITS: THE MANNVILLE GROUP, WCSB (ALBERTA, CANADA)

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The growing attractiveness for the unconventional resources in the recent years renewed the economic and the scientific interest for source rocks. Therefore, characterizing the organic matter rich-deposits, forming the source rock of a petroleum system, has become a recurrent topic in scientific debates. A relevant point is the understanding of the distribution and composition of the source rock deposits throughout a basin The significant accumulation of organic matter is the result of specific circumstances in the basin, which determine the occurrence of favorable conditions for organic matter in the rocks to be accumulated and preserved. In the case of the terrestrial depositional settings, the occurrence of these conditions is the result of the interaction of several factors acting on the base level (among others, subsidence, accommodation, climate, primary productivity and topography). Therefore, in order to understand the processes that favor the deposition of abundant terrestrial organic matter, it is necessary to have a complete comprehension of the tectono-sedimentary evolution of the basin, where these deposits form. Climatic and eustatic oscillations also need to be considered and reconstructed.

This study aims to reconstruct the stratigraphic architecture of the subsurface coal bearing Mannville Group deposits (Lower Cretaceous, Western Canada Sedimentary Basin, South and Central Alberta). Particularly, the occurrence of coal strata within the stratigraphic interval is characterized, by focusing on their geometry, extension and distribution. To this scope, firstly two regional well correlation transects, calibrated by core sedimentological analysis, were established. The Mannville Group was subdivided into system tracts: a lowstand system tract (LST), which corresponds to the Lower Mannville Fm., a transgressive system tract (TST), corresponding to a backstepping phase of marine transgression, and finally, a highstand system tract (HST) that corresponds to the “undivided” Upper Mannville.

In a second step the geometry, distribution and extension of the coal layers are examined within the sequential framework previously reconstructed. Four different zones where coal seams have occurred have been identified: LST-TST, early HST, middle HST and late HST. Thinner and more restricted coal layers are formed during the lowstand and transgressive system tracts and also during the late highstand system tract. Thicker, more extensive coal layers are accumulated during early highstand, as a result of the interaction with the topography, which is partly smoothed during the deposition of the Mannville Group and the changes to the accommodation space through time.

VARIATIONS OF THE MARINE CARBON ISOTOPE SIGNAL ACROSS THE SANTONIAN/CAMPANIAN BOUNDARY. NEW DATA FROM THE FLAMBOROUGH CHALK FORMATION, EAST YORSHIRE, UNITED KINGDOM

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The Santonian/Campanian boundary is marked by a global $\delta^{13}C$ positive excursion (Santonian/Campanian boundary event SCBE), which is characterised by a limited variance (around +0.3‰) in the Boreal and Tethyan realms. The SCBE has been well studied in the Southern chalk Province of England but there are only limited data available in the Northern chalk Province. Notice-able differences in the chalk of the two Provinces (eg. variations of thickness, stiffness and porosity, lack of flints in the North) require better, highresolution correlations across England. In this study, the Flamborough Chalk Formation of the Northern chalk Province (Danes Dyke section – East Yorkshire) has been sampled for isotope analyses to test for the expression of the SCBE in northern England and to further improve correlations between the Southern and Northern Provinces. Mm to cm-scale marl seams have also been sampled for XRD analyses in order to characterise the potential variations in the detrital influx and clay assemblages between the top of the Santonian and the Base of the Campanian.

In the Flamborough Chalk Fm and elsewhere, the Santonian/Campanian boundary is defined by the last occurrence (LAD) of the crinoid *Marsupites testudinarius*. Our Isotopic results show that the SCBE is characterised by a double positive excursion with maximum $\delta^{13}C$ values of +2.83‰ (peak "a") and +2.89‰ (peak "b"), and a minimum value of 2.51‰ measured in-between the two peaks. The first excursion lies in the uppermost part of the *M. testudinarius* zone and therefore belongs to the upper Santonian. The second excursion is located above the LAD of *M. testudinarius* and is thus partially included in the *U. anglicus* biozone of the lower Campanian. The clay assemblage within the various marl bands is dominated by R0 type illite/smectite mixed-layers (94% to 97%) and subordinate illite (6% to 3%) with very little variations.

Correlations with published key sections in England (eg. Seaford Head, Trunch borehole) show that the overall SCBE has a similar signature and can be used to refine regional correlations, although it is thicker in the Northern Province possibly due to higher sedimentation rates in this area (c. 6 m thick at Seaford Head versus c.15 m at Danes Dyke).

EARLY-MIDDLE MIOCENE PLANKTONIC FORAMINIFERAL PROVINCIALIZATION: A COMPARISON BETWEEN THE EQUATORIAL ATLANTIC ODP SITE 925 AND THE MEDITERRANEAN HIGH RESOLUTION QUANTITATIVE BIOSTRATIGRAPHIC RECORDS

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The early–middle Miocene represents a crucial period in Earth's climate evolution; it is characterized by the Middle Miocene Climatic Optimum (MMCO, ~17~15 Ma), followed by a gradual decline in temperature during the Middle Miocene Climate Transition (MMCT, 1514 Ma) and culminating in the marked Mi3b cooling event at 13.8 Ma. The ocean-climate system changed to a colder mode and progressed to modern conditions marked by strong meridional and vertical thermal gradients, increased zonality and dominance of high-latitude deep water sources. This evolution favoured the contraction of tropical and subtropical bioprovinces to lower latitudes and planktonic foraminiferal assemblages started to differentiate between low- and mid-latitude regions. Moreover, the combined effects of climate change and geodynamic evolution caused the provincialization of the Mediterranean since the middle Miocene. All this led to the erection of different biozonal schemes for the (sub)tropical regions and the Mediterranean area. High-resolution quantitative biostratigraphic studies and a good age control (e.g., by the integration with magnetostratigraphy and cyclostratigraphy) are fundamental to improve biostratigraphic resolution and global correlation. The enhanced accuracy of age calibrations improved the evaluation of the degree of synchronism or diachronism of late Neogene biostratigraphic events and the understanding of spatial and temporal distribution of biostratigraphic markers. As it concerns the early-middle Miocene interval, recent high resolution biostratigraphic studies from Mediterranean astronomically-tuned deep marine successions highlighted discrepancies in age calibration of the main bioevents with respect to the low latitudes. In particular, the evolutionary stages of the Praeorbulina-Orbulina lineage resulted younger in the Mediterranean than at the low latitudes as reported in the literature.

Here, we present the results of high-resolution quantitative biostratigraphic analysis of the planktonic foraminiferal assemblages from the astronomically tuned Site 925 (ODP Leg 154-Equatorial Atlantic Ocean). The investigated interval is made up of nannofossil limestone-chalk with foraminifers and clay and shows an evident sedimentary cyclicity. This biostratigraphic analysis, carried out with a much higher time resolution (~20 kyr) compared to the previous studies, allows us to obtain the quantitative distribution patterns of the marker species and to refine the stratigraphic position and the age calibration of the main events which define the (sub)tropical M3 to M7 Zones. The biostratigraphic record of Site 925 has been correlated with those previously published from the Mediterranean. In particular, we consider the La Vedova section (Ancona, Italy), which belongs to the lower portion of the Schlier Formation, a (hemi)pelagic unit deposited in the eastern part of the Umbria-Marche basin. The comparison of these successions, independently astronomically-tuned, allows us i) to evaluate the degree of diachronism of the main events recorded both at low latitudes and in the Mediterranean (e.g., the first occurrences of the evolutionary stages of *Praeorbulina-Orbulina* lineage, *Globorotalia archeomenardii* and *G. praemenardii*), and ii) to highlight differences in the distribution patterns of marker species (e.g., *Paragloborotalia siakensis*, *Globorotalia peripheroronda*, *Globigerinoides subquadratus*) between these two areas that could reflect variations of water-masses characteristics related to the early-middle Miocene paleoclimatic-paleoceanographic evolution.

OOIDS: THE UNRECOGNIZED MICROBIALITES

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Marine ooids are spherical concretions with cortical laminae of tangentially arranged aragonite crystals that accrete around a nucleus. Unlike thrombolites and oncoids, whose microbial origins are well recognized, ooids traditionally are viewed as abiotic grains. Yet, the presence of microbes in ooids is well documented. In fact, the level of microbial diversity exceeds stromatolite-thrombolite systems. Microbes are known to orchestrate $CaCO_3$ precipitation in microbialite systems, and are here proposed as agents for the formation of ooids. Herein, we use a suite of analyses that include DNA molecular analyses, solid state ^{13}CNMR, geochemical and scanning electron microscopy analyses to identify signatures indicative of processes associated with ooid accretion and carbonate precipitation in the active shoals of the Bahamas. This study reveals that modern marine ooids not only harbor a rich and diverse community of microbes with a wide range of metabolic processes associated with $CaCO_3$ precipitation (e.g. denitrification, photosynthesis, sulfate reduction, etc.) but ooids undergo a complex diagenetic history throughout their lifespan driven by the syntrophic interaction of microbes with capabilities for carbonate precipitation or dissolution. Using scanning electron microscopy (SEM), we identify wellpreserved microbial assemblages and provide evidence of biogenic signatures intrinsically related with organomineralization including, extracellular polymeric substance (EPS) exudates from biofilm forming bacteria and diatoms; imprints of EPS degradation by heterotrophic bacteria; amorphous calcium carbonate (ACC) precipitates within micro-domain areas of biofilm EPS; and extracellular precipitates on bacterial cells. Furthermore, the ubiquitous presence of EPS matrices along with EPS producers in the outer and inner cortices of the ooids, supports the imminent role of biofilm communities in $CaCO_3$ precipitation. This study also provides direct evidence on the presence of amorphous calcium carbonate (ACC), a metastable carbonate polymorph that appears to act as a transient precursor phase in the early phases of ooid cortex accretion. The latter is supported by multiple lines of evidence that include SEM analyses documenting nanograin structures similar in size and morphology to typical ACC grains together with the Mg/Ca of leached ooids, which follows those of biogenic produced ACC. Further line of evidence is supported by solid-state NMR with ^{1}H-^{13}C cross-polarization analysis, which documents a broad resonance peak (168.5 ppm) similar to those of pure-synthetic ACC. As revealed by NMR and SEM, ACC plays a formative role in the formation of aragonite crystals in ooids. Contrary to the classical nucleation theory, aragonite mineralization in ooids occurs through pre-nucleation of ACC whose intimate association with EPS and microbes suggests that ACC are biomediated precipitates. These findings argue for a new conceptual model for ooid accretion that include a biomediated ACC metastable phase.

GLACIAL AND INTERGLACIAL SEDIMENTARY RECORD IN CROSS-SHELF VALLEY: EVIDENCE FOR PERMO-CARBONIFEROUS ICE-MARGIN FLUCTUATIONS (DWYKA GROUP, SOUTH-EASTERN SOUTH AFRICA)

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The Gondwana-wide Permo-carboniferous glaciogenic deposits, known as the Dwyka Group in South Africa, form the basal succession of the classic Karoo Supergroup. In south-eastern South Africa, these deposits are commonly viewed as bearing the record of a single deglacial event. Conversely, its western equivalent (Namibia and western South Africa) is assumed to record four stages of growth and decay of ice masses separated by intermittent interstadials. The present work reveals, however, that at least three icemargin fluctuation sequences, formed by both glacial and non-glacial facies, form the infill of 100 m deep, 1-3 km wide U-shaped cross-shelf paleo-valleys carved into the bedrock. These valleys possibly represent paleo-fjords as observed elsewhere in Southern Gondwana but not recognized as such in this part of the Karoo Basin so far.

In the studied area (KwaZulu-Natal province), three superimposed units displaying both glacial and non-glacial signatures compose the Dwyka Group. The up to 70 m thick lower unit consists of massive diamictite bearing abundant up to boulder-sized lonestones. This lower unit wedges out and onlaps on valley flanks while its top is characterized by glacial striae and grooves. Above, the 50 m thick coarsening-upward sequence forms the second unit which also consists in massive lonestone-bearing diamictite interstratified by normally-graded sandstone beds devoid of lonestones. These facies grade upward into a 10 m thick trough and sigmoidal cross bedded conglomeratic sandstones that is locally highly disturbed by subglacial deformation. The third unit formed by a massive diamictite bearing carbonaceous concretions and rare pebblesized lonestones is topped by discontinuous patches of highly glacially-deformed conglomeratic sandstones. Black shales of the Ecca Group, usually interpreted as postglacial deposits, directly rest on this ultimate glacial surface.

Although diamictite intervals likely result from deposition in a glaciomarine environment by important rain-out beneath or immediately in front of a floating ice shelf, cross bedded and normally-graded sandstone horizons, respectively interpreted as fluvioglacial and subaqueous sediment density flows deposits, indicate local ice-free conditions. The vertical superimposition of these facies are then strong indicator of ice margin fluctuations throughout the study area. In such a context, the glacial maximum is likely marked by the basal erosion surface that carved valleys into the bedrock while the glacial surface recorded on top of the first unit is suspected to represent a temporary stillstand marked into an ice margin retreat. Deformed sandstones on top of both the second and third units thus represent fluvioglacial deposits emplaced during ice free conditions in a context of relative sea level fall forced by the glacio-isostatic rebound and deformed by subsequent ice margin advance. Conversely, marine and glaciomarine deposits resting on top of these deformed beds are interpreted as being deposited by rapidly retreating ice margin in glacio-isostatic depressions.

RECONSTRUCTING ICE MARGIN RETREAT USING DELTA MORPHOSTRATIGRAPHY: THE CASE OF THE LAURENTIDE ICE SHEET

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The pattern of the final inland retreat of Quaternary ice masses is most often constrained by the systematic mapping of moraines and glacial lineations which direct dating is problematic due to the paucity of datable material. Unravelling final deglacial stage is, however, crucial as it relates to continental-scale ice flow oceanic circulation reorganisations and important climate change. In contrast, deposition of deltaic systems formed by glaciogenic sediments transported by glacial meltwaters, although partly determined by rapidly falling relative sea level forced by glacio-isostatic rebound changes, are also controlled by change in sediment supply, itself intimately tied to the history of ice margin retreat throughout watersheds. Then, delta architectures and morphostratigraphies, typified by detailed temporal framework which the accuracy in Quaternary depositional systems is higher than the century, have a great potential to provide additional and independent age constraints for ice sheet ablation in delta watersheds. In this study, we integrate geomorphological and sedimentological results from twenty deltaic complexes constructed immediately after the retreat of the Laurentide Ice Sheet (LIS) from the St. Lawrence North Shore Shore (eastern Canada) ca. 11 kyr ago. Based on delta architecture and morphostratigraphy, three depositional systems reflecting the pattern of ice margin retreat have ben deciphered. During early stage of deglaciation, ice margin anchored on bedrock pinning points and led to the deposition of ice-contact outwash fans. The subsequent inland retreat of the ice margin generated glacial meltwaters that fed the proglacial deltas in glaciogenic sediments. The melting of the ice margins out from river watersheds is recorded by the shutdown of delta progradation, severe fluvial entrenchment and deposition of shallow-marine strata dominated by coastal processes (paraglacial suites). The spatial and stratigraphic distribution of these three depositional systems have been categorized into four end-member scenarios representing both the inherited basin physiography (extent of the watershed) and retreat of the ice margin (early vs. late deglaciation). Interpreting deltaic complexes along ~1500 km of coastline allows us to map the positions of Late Pleistocene-Early Holocene inland ice fronts of the retreating LIS margin during the progressive deglaciation of the watersheds of these deltas, together representing > 250.000 km^2 in area.

DEGLACIAL SEQUENCES AND GLACIO-ISOSTATIC REBOUNDS: QUATERNARY VS. ORDOVICIAN GLACIATIONS

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Post-LGM (LastGlacialMaximum) deglacial sequences are dominated by backstepping grounding zone wedges (GZWs) and ensuing deltaic and coastal successions. While the grounding line position governs sediment entry points in the early deglacial epoch characterized by glaciomarine environment, the relative sea level (RSL) fall forced by the glacio-isostatic rebound (GIR) along with basin physiography exert a major control on the sedimentary architecture of succeeding delta systems. Field examples and numerical stratigraphic modeling show that Quaternary forced-regressive ice-contact, deltaic then coastal deposits are an essential element of deglacial sequences which should have an equivalence in the deep-time glacial record. Here, we thus compare a Late Pleistocene and a Late Ordovician deglacial sequences, along the Québec North Shore (Estuary and Gulf of St. Lawrence, eastern Canada) and Anti-Atlas (southern Morocco) respectively.

Along the Québec North Shore, GZWs and ensuing ice-contact glaciofluvial wedges been first emplaced. Subsequently, after the inland retreat of the ice margin, proglacial fluvio-deltaic wedges accreted throughout fjords and shelf. In spite of the effective RSL fall (several cm per year) forced by the GIR, no fluvial entrenchment occurred at that time owing to active sediment supply. After the melting of ice margin out from the watersheds, river incised drastically into former deposits and offlapping beach ridges essentially remobilized glaciomarine and proglacial sediments. The resulting succession is a twofold, sand-dominated, 20-150 m thick sequence that fines then coarsens upward essentially deposited in less than 3 kyr. The intermediate fine-grained interval mimicking a MFS rather represents the turnaround from glaciomarine (subaqueous sediment entry points) to continental (subaerial entry points) ice margin. Counterintuitively, the onset of fluvial entrenchment does not relate to the inception of forced regression but to the retreat of the ice margin from watershed in the context of reduced rate of RSL fall.

The last glacial sequence observed in Morocco shows a similar stratigraphic pattern, superimposing a basal fining-upward parasequence (10-50 m) formed by glacially-influenced facies (glaciomarine facies, outburst-flood deposits) and an overlying coarsening-upward delta succession (40-70 m) devoid of any glacial signature. This whole sequence might be ascribed to a single deglacial event recording the retreat of the ice margin and the shallowing forced by the associated GIR. If analogue, one of the thickest sediment wedge constituting the archive of the Ordovician glaciation only represents a few thousands of year of deposition within a much longer (> 1 Myr?) glaciation.

UNRAVELLING PAST AND PRESENT GEOTHERMAL STATES OF THE GREATER GENEVA BASIN THROUGH AN INTEGRATED ANALYTICAL APPROACH

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The geothermal potential of the Greater Geneva Basin (GGB) in western Switzerland is today under investigation by a variety of exploration activities. In order to study the geothermal evolution of the basin an integrated study combining geostatistical temperature modelling, fluid inclusions (FIs), source-rock maturity, and petroleum basin modelling has been carried out.

Bottom-hole temperatures were analysed from 26 existing wells located in and around the GGB revealing a present-day geothermal gradient of ca. 30°C/km for at least the first 5 km. A 3D geostatistical temperature model of the basin has been generated to produce probabilistic maps of target isotherms of 70 and 140°C. This model also highlights a series of positive and negative thermal anomalies that are interpreted as the result of heat advection caused by fluid circulation along faults and/or karst systems.

Deeply buried Mesozoic rocks in the GGB also contain organic-rich layers that may be considered as hydrocarbon source-rocks. Vitrinite reflectance analysis from the Upper Jurassic (2200 m-depth) and the Carboniferous (3000 m-depth), give values of 0.73% and 1.14% respectively. These values are higher than the expected reflectance given the present-day thermal state of the basin and suggest the occurrence of an ancient higher geothermal gradient. Oil and gas seepage analysis show that these source-rocks are currently expelling hydrocarbons migrating through the entire stratigraphic column.

Ba-Pb-Zn mineralizations infilling fractures and veins have been recognized in the the Buntsandstein sandstones (Lower Triassic) Microthermometry and isochores analyses of FIs hosted in hydrothermal quartz overgrowth over detrital quartz and associated with the mineralization give minimum trapping temperatures comprised between 115°C (considering a near surface pressure) to 150°C (considering current sample depth of 3000 m) which is higher than the currently recorded temperatures in the basin. These further suggest that the GGB was once warmer.

In order to simulate the tectonic, stratigraphic and thermal history of the basin, a 1D petroleum system modelling has been computed based on the Humilly-2 well. The best-fit model, fitting the present-day temperature and source-rocks maturity, predicts maximum burial pressure and temperature conditions in the Miocene and the deposition of the Alpine Molasse. Similarly, according to the predictive basin modelling, the P-T conditions of the mineralizing fluid, inferred from FIs, most likely occurred in the upper Miocene ages.

Alternative sedimentary basin evolution models will be discussed based on to the source rock maturity and discrete geothermal events which may have affected in the GGB as they are known to have occurred in the surrounding areas.

THE CHARACTERISTICS AND MODEL OF PRIMARY MIGRATION FOR SHALE OIL

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There are kinds of reservoir space including organic pores, intragranular pores, intergranular pores and fractures, which are primary migration channels for bitumen in the oil-generation shale. Comprehensively use thin section analysis, SEM and thermal simulation experiments to explore the characteristics of primary migration. The research shows bitumen mainly exists in the form of free state and has obvious flowing sign, rapid pressurization resulting from hydrocarbon generation of kerogen makes bitumen discharged into the intergranular pores between kerogen and inorganic minerals by organic pores and micro-fractures in kerogen, under the pore fluid pressure, bitumen preferentially selects the large scale of reservoir space including intergranular pores of felsic minerals, intercrystalline pores of carbonate minerals, intracrystalline pores of clay minerals and expulsion fractures in the horizontal direction, bitumen gradually converges into a larger scale of reservoir space such as dissolution pores, bedding fractures and structural fractures, and vertically migrates by high-angle structural fractures, and according to the occurrence type and flow pattern of bitumen changing with the variation of reservoir space including type and scale, establish the gradually gathered and multi-scale transport model of primary migration of shale oil.

OSL-BASED ABSOLUTE AGE DATING OF ALLUVIAL RIDGE FORMATION AND ASSOCIATED RIVER AVULSION IN A HOLOCENE LOW-GRADIENT DRYLAND-RIVER SYSTEM: ALTIPLANO BASIN, BOLIVIA

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Dryland rivers are characterized by the gradual downstream decrease in width and depth in the lowgradient coastal plain trajectory. In scarce, punctuated flood periods, the peak-runoff volume by far exceeds the bankfull river capacity and leads to massive flood-outs with formation of an extensive sheet complex of amalgamated crevasse splays and terminal splays at the river terminus. Sediment accumulation reduces the along-river gradient and eventually results in upstream river avulsion.

In this study, the combination of absolute age dating of avulsion frequency with Optically Stimulated Luminescence (OSL) measurements, remote sensing data analysis and differential GPS (dGPS) profiling is employed for the analysis of processes and timing of meander-belt avulsion and the resultant sedimentary architecture of the Holocene Río Colorado in the endorheic Altiplano Basin (SW Bolivia).

At present, the basin is in a dry climate lowstand period, and the Río Colorado rapidly expands over the exposed lacustrine and evaporite deposits. The sedimentary architecture at the terminus of the Rio Colorado comprises a network of wide, low-elevation alluvial-ridge sand and silt deposits. The network originated from successive meander-belt switching as the result of multiple avulsions in a time period of only 4600 yr, with avulsion frequencies ranging from 200 to 900 yr. The total area covered by these deposits approximates 500 km^2, and the maximum total thickness of the fluvial sediment is 3 m. The topographically-elevated alluvial ridges formed by aggradation of sand in point bars, natural levees and laterally-amalgamated crevasse splays. The bankfull river width decreases downstream from 70 m to less than 10 m, and the depth from 1.8 m to less than 0.5 m over an along river distance of 28 km. Individual ridges have a low elevation and attain a total width in the order of 1500 m. Increase of in-channel accommodation by levee aggradation led to simultaneous sand accumulation on the channel-floor and growth of the river above the floodplain level. The positive relief formed in this manner decreased the along-river gradient while increasing the cross-floodplain gradient, and is the direct cause of river avulsion. When subsequent meander-belt positions are in the proximity of older alluvial ridges, onlap of crevasse splays onto the adjacent ridge leads to larger aggradation in the confined inter-channel areas, and a topographically higher elevation than in the unconfined floodplain. Subsequent river positions avoided the positive relief, and lateral juxtaposition of successive alluvial ridges resulted in compensational stacking and amalgamation of fluvial sand deposits to a laterally connected alluvial-ridge network.

SHALLOW AQUIFERS IN MEANDERING-RIVER DEPOSITS AS THE LOCUS FOR LARGE-SCALE ARSENIC POISONING: CASE STUDY FROM THE MIDDLE GANGES PLAIN IN BIHAR, INDIA

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Arsenic of geogenic origin is abundantly present in the shallow-aquifer domain of Holocene fluvial and deltaic deposits in sedimentary basins around the world. Arsenic concentration levels in the mostaffected areas such as the Middle Ganges Plain (Bihar, India) and the Ganges-Brahmaputra-Meghna Delta (Bangladesh) are characterized by large lateral and vertical variability over short distances, and by values of up to 1800 µg/L, which by far exceeds the 10 µg/L upper limit for safe drinking water recommended by the World Health Organization. Long-term intake via consumption and irrigation leads to arsenic poisoning (arsenicosis).

In the present study an analysisis presented of the relation between the spatial variability of arsenic concentration levels and fluvial facies distribution, based on arsenic concentration measurements in shallow hand-pump wells, lithofacies analysis from cored wells in a point bar and adjacent clay plug, Google EarthPro analysis of fluvial geomorphology, and side-scan sonar depth profiles of partly-filled oxbow lakes, all in Holocene meandering-river deposits of the Ganges River in Bhojpur District (Bihar, India).

Highest concentrations are in the shallow aquifers (down to 50 m depth) of fluvial point-bar sands. The surrounding oxbow lakes are characterized by high sedimentation rates comprising clay and silt with high organic matter content. The anoxic conditions in the hypolimnion of the oxbow lake, and the organic carbon-rich clay-plug sediment form the boundary conditions, where reactive organic carbon triggers the release of arsenic by microbially-mediated reductive dissolution of arsenic from its solid state in iron-arsenic oxy-hydroxides and arseno-pyrite. Total arsenic in the clay plugs was calculated from bulk sediment volume calculations in combination with concentration levels in sediment cores. On the basis of the juxtaposition of point-bar sand and clay plug, the lithofacies characteristics and inherent permeability differences, and the omnipresence of the two geomorphological elements in Holocene meandering-river settings, a generic model is proposed for the release of arsenic from its solid state and subsequent migration of dissolved arsenic from the low-permeable clay plug to the adjacent permeable point-bar sands by the process of diffusion. Accumulation and increase of arsenic concentrations occurs when the point bar is completely surrounded by clay plugs (so-called four-way entrapment). Villages in the area are preferentially located on the topographically-higher point bars, and water extraction by the inhabitants with hand-pump wells creates a pressure gradient that draws the arsenic-enriched groundwater to the wells and thus aggravates the risk of arsenicosis.

"A LITTLE BIT, BUT NOT A LOT": HOW TO UNRAVEL THE EXPLORATION POTENTIAL OF MARGINS WITH VERY VARIABLE MAGMATIC BUDGETS

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Magma-poor and Magma-rich have become common terms in our descriptions of passive margins. There are many beautifully illustrated examples in the literature describing the features of both margins and the differences in their evolution. In many cases margins fall between these two end members. These margins, in contrast to their end member siblings, are poorly described and can often be variable in their form. We will call these margins hybrids.

In this abstract we describe some of the features and exploration challenges when faced with variable magmatic budgets. Our examples will come from proven world class hydrocarbon provinces: the Sergipe Alagoas-North Gabon/Rio Muni Conjugate margin.

Tectonically this conjugate pair sits at the edge of the Congo Francisco craton. Their tectonic position may be the trigger and cause of very variable magmatic budgets. Unlike magma rich margins, it does not appear that these margins developed from a large igneous event or hotspot. Yet many features we associate with magma rich margins can be observed (SDRs for example). The ability to produce magma certainly exists and perhaps it's the highly reworked rock present at the edge of a Craton that is more prone to melting than the less altered rock in the centre of the craton.

The complexity in distribution of magma means that care needs to be taken when approaching exploration as classic approaches, techniques and technology can often be misleading.

One of the hardest tasks in a hybrid margin will be describing the composition and thickness of the crust and the landward position of true oceanic crust. Public available gravity data does not provide the resolution to see the sharp and rapid variations. High resolution marine gravity data is a must and its interpretation needs to be carefully coupled with seismic observations. Highly thinned, infiltrated or altered continental crust approaches densities similar to oceanic crust, so gravity alone cannot provide the answers. Magnetic data shares a similar problem over the continental section of the crust. Areas infiltrated with magma can have the appearance of 'stripy' oceanic crust. The magma can artificially thicken the crust, causing overestimation of crustal thickness, a key input to describing subsidence and heatflow on any margin.

Subsidence and heatflow form the framework for any play based exploration approach. Subsidence dictates the type and rate of sedimentation and heatflow the maturation and associated diagenetic behaviour of sediments. The magmatic budget plays a critical role in their behaviour. In a hybrid margin where these can vary rapidly spatially, it is our recommendation that as early as possible in the exploration campaign you acquire a large 3D to capture the subtle and rapid lateral variations.

We will outline the observations and variations of a hybrid margins; discussing subsidence, stratigraphy, heatflow and exploration potential.

SEDIMENTARY FACIES CHARACTERISTICS ANALYSIS OF AN ANCIENT LACUSTRINE SHALLOW WATER DELTA SUCCESSION UNDERGROUND: IMPLICATION FOR THE CONSTRUCTION AND PREDICTION OF DISTRIBUTARY CHANNELS

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The shallow water delta sandbodies are important hydrocarbon exploration targets in Mesozoic lacustrine basins in China. In recent years, shallow-water delta deposits have been found in the Nenjiang Formation in south of the Songliao Basin, China. Since the distributary channels of delta are main sand deposition area as well as oil and gas reservoirs, it is important to get accurate description of distributarychannel distribution when looking for hydrocarbon reservoirs. In this paper, through integral studies on field crops, cores, 3D seismic data, well-logs and laboratory sediment analysis, sedimentary facies and processbased genetic model has been constructed in the first sandbed of the third member of the upper Cretaceous Nenjiang Formation (Nen 3 member for short) in the Qian'an area, Southern Songliao Basin. Results show that the main sedimentary sub-facies of the shallow water delta is composed of delta plain, delta front and prodelta (shallow lake). The sub-facies are further subdivided into several sedimentary micro-facies mainly including distributary channels, interdistributary channels, terminal distributary channels, mouth bars, and sheet sands. The shallow water delta of the Nen 3 member developed in humid paleoclimate with gentle gradient during lacustrine regression stage. The sediment source of Nen 3 member mainly comes from northeast of the Qian'an area with abundant sediment supply. The dendritic-like distributary channels are widely developed and moved towards the center of the lacustrine basin gradually with frequent bifurcations and formed framework sand bodies. The terminal distributary channels and mouth bars can be identified at river mouth of delta front using plane seismic attributes. During high sediment supply stage, the mouth bar sands keeps short time and get incision by progradation of the distributary channels. During low sediment supply stage, the delta front sediment is reworked by wave action and formed sheet sands. The mouth bar sands, sheet sands, distal bar sands are not frame sandbodies because of the distributary channels incision at terminal position and reworking of lake waves. Dynamic process-based sedimentary model of shallow water delta distributary channels is built from underground geological data of Nen 3 member and modern sedimentary analog. According to practical exploration, the distributary channels sands of Nen 3 member formed the most important favorable reservoirs. This study is important for improving the understanding of the lacustrine shallow water delta deposition process and plan-view shapes depiction or prediction of thin distributary channels during the Late Cretaceous period and hence important for the predictive aspects of the favorable deltaic reservoirs in the Songliao Basin.

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CONFINED ZONE OF SLUMPED AND DEFORMED BEDS ON THE NORTHERN ECUADORIAN COAST, THE SIGNATURE OF PROXIMAL TURBIDITY CURRENT ONSET?

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This contribution presents preliminary field data about an anecdotic, very confined zone of highly deformed beds in an offshore succession from North-West Ecuador. The outcrop can represent a field example of a proximal destabilization zone triggering turbidity currents.

The outcrops from the sea cliffs of Las Peñas village (North-West Ecuador) present a zone with partial or total loss of stratification over an extent of several hundreds meters laterally and at least 20 m in height, in otherwise well stratified beds. The encasing succession consists of sandy siltstone and siltstones planar beds of likely offshore origin from the Borbón basin (Upper Miocene). Numerous faults are present in this region, presently highly seismogenic (e.g. 1979 Tumaco Earthquake).

The anecdotic zone includes convolute beds with flame structures showing no particular orientation, conglomerates with pebbles (ca. 20 cm diam.) in a matrix of the same material as the conglomerate but finegrained and including shells, and completely massive beds with shell fragments.

The Northern limit of the anecdotic zone is a subvertical (ca. 80°), straight contact between deformed beds and completely intact strata. Few “dikes” (0,1-1 m thick) consisting of highly deformed beds with flame structures radiate from the anecdotic zone and vanish away from it. They are interbedded between the intact beds, and can be followed over distances of tens of meters.

The anecdotic zone can be followed seaward until erosion of the outcrop. The top of the zone consists of terrestrial sediments with no stratification, and no undisturbed covering beds were recognized.

The convolute beds within the anecdotic zone probably indicate some slump-like behavior at the base of a less coherent flow, represented by the massive beds. The presence of conglomerates suggests that the moved beds were partially consolidated, or at least well compacted, and the presence of shells (absent from the encasing sediments), indicate that the transport was initiated from shallower depths. The “dikes” of deformed beds radiating from the anecdotic zone can indicate that an overpressure was sustained by a moving flow, and that fluids entered between the stratae and partially fluidized some intraformational weaker beds.

The deformed anecdotic zone may be related to a fault zone and earthquakes, yet a flow seems clear, and may have been the trigger for a larger turbidity current. The outcrop likely represents the very proximal onset of such a density current and is a rare and well preserved signature to document the processes involved in such events.

PYROCLASTIC DENSITY CURRENTS AND SUBAQUEOUS DENSITY CURRENTS: BROTHERS IN LAW(S)?

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Pyroclastic Density Currents (PDCs) are particulate density currents triggered by explosive volcanic eruptions. They consist of a flowing mixture of gas and volcanic clasts that hurtle down the flanks of a volcanic edifice, driven by the excess density supported by the particles. The main difference compared to other types of landslides or avalanches is that volcanic rocks are generally highly breakable and prone to produce large amounts of fines. Here, a variety of singular PDC sediment features is presented, based on field observation from more than fifteen volcanic areas. The contribution is axed on the comparison with density currents from subaqueous environments.

Deposits from PDCs with low particle concentration (supported by air turbulence) often consist of fields of dune bedforms with an evolution in terms of size and morphology as a function of flow energy and particle supply. Dune bedforms produced by PDCs (1 to 30 m in length) are generally characterized by their stoss aggrading nature and absence of migration. This means that they have a stable position, yet the crest of a structure is generally growing in the upstream direction due to favored deposition on the stoss-face. A variety of patterns are observed, from very low angle bedforms similar to the hummocky-cross-stratification in tempestites, to steep sided (> 35°) aggrading bedforms. Low to steep angle sigmoidal layers building up against steep truncation planes also occur. Several evidences point toward a bed-topography influence of the aggradation patterns rather than an interpretation as supercritical antidunes or cyclic steps.

Erosion planes within bedforms as well as substrate entrainment by flow bulking are evidenced both from the architecture of sediment structures and the components found in the deposits. PDC deposits may consist of several 10s % of entrained material. Large blocks (> 1 m diam.) can be transported in otherwise sand-sized material. Erosion planes can take any geometry, from subhorizontal to vertical. Interestingly, those erosion planes often exhibit overturned, soft-sediment deformation features that affected a belt of few cms below the truncation plane. These features may be the natural record of the turbulence intensity within PDCs, and a gate to access quantitative information.

In terms of granulometry, the grain size variations between individual laminae are both more contrasted, and with less clearly defined laminae as within subaqueous equivalents. This is probably a result of high turbulence, the effect of the strong density difference between air and particles, and the short duration of an event, that makes deposition almost continuous. Laminated deposits are limited to a specific range of median grain sizes and sorting. Neither the crooked, angular shape of particles, nor the occasional occurrence of liquid water (making the system a 3-phase mixture) seem to have an influence on bedform geometries or grain size characteristics.

Many of the features documented from PDC deposits can find their equivalent in sediments from subaqueous density current. We hope to trigger a discussion on the common observations and on the dynamics at the source of the sedimentary signatures.

ON THE TERMINATION OF FAN CHANNELS: EXAMPLES FROM THE RHÔNE FAN (GULF OF LIONS, WESTERN MEDITERRANEAN)

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The Rhône turbidite system is the largest sedimentary accumulation in the Gulf of Lions. It was fed by the Rhône inputs delivered to the basin by the Petit-Rhône Canyon. Separated from the Rhône River mouth by a 100 km-wide continental shelf during high-sea level periods, it became connected by an incised valley during low stands of sea level. The Gulf of Lions basin and distal parts of the Rhône Fan are deformed by diapirs of Messinian salt. We present a high-resolution geophysical study conducted on the terminal parts of the Petit-Rhône recent channels in the framework of Eurostrataform European Program. Seven successive main channels (6 to 1 and N, from the oldest to the youngest) avulsed and distributed sediments into the basin resulting in a radial distribution pattern. Except the Neochannel (N), i.e. the youngest channel that avulsed 20 cal ka ago and was abandoned 18.4 cal ka ago, each of the main channels created sub-channels that represent groups evolving by avulsion. We focused our study on the 3 youngest groups (2, 1 and N), on the basis of relief map and sub-bottom profiles. The distributary channels of groups 2 and 1 create elongated finger like morphological bulges on the seafloor. The Neochannel is short, and do not create morphological bulge because it was emplaced up on the fan, where gradient was higher, but is prolonged by an elongated 170 km-long, 30 km-wide depositional part including several terminal lobes, obviously controlled by nearby older sedimentary bodies of the margin. The upstream-downstream morpho-structural evolution of the channels is linked to gradient changes and defines 3 main domains, i.e. (i) aggradational channel-levee system where depositional processes are dominant, (ii) Channel Lobe Transition Zone with scours and unconnected channels indicative of the dominance of erosional processes, and (iii) stacked 10 m-thick terminal lobes attesting of the dominance of depositional processes. This model of upstream-downstream evolution is well expressed in the Neofan, and more faintly recognized for the older channel-levee-lobe systems of the fan, possibly due to the combination of lower resolution of bathymetric data in greater depths and topographical attenuation by hemipelagic deposition since abandonments at least 20 cal ka ago. Syn-sedimentary deformations and sediment partitioning by salt tectonic also probably contribute to alter observation of morphostructural evolutions.

TOTAL ORGANIC CARBON CONTENT AND CARBON STABLE ISOTOPES IN THE SINEMURIAN SHALLOW-WATER CARBONATES (COIMBRA FORMATION) OF THE LUSITANIAN BASIN, PORTUGAL

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The first truly marine carbonate deposits in the Mesozoic sedimentary successions around the western Iberian margin are dated from the Lower Sinemurian. In the western sector of the Lusitanian Basin (Portugal), the Sinemurian series record the evolution from inner (Coimbra Formation) to outer (Água de Madeiros Formation) marine carbonate ramp settings. In this sector, the Coimbra Formation is particularly well exposed at S. Pedro de Moel, where it is subdivided into 8 informal subunits (A–H). Except for its base, composed of dolostones, dolomitic limestones and microbialites (subunits A to B), much of the succession consists of bioclastic and micritic limestones (mudstones to packstones) generally alternating with centimetric marly layers. *Thalassinoides*, *Rhizocorallium*, bivalves, gastropods, echinoderms and brachiopods are particularly abundant, the later benthonic group exclusively occurring at the top of the Formation (subunit H). Ammonites date the middle part of the Coimbra Formation (top of unit D to F) from the *Obtusum* Zone (lowermost Upper Sinemurian). Within this stratigraphic and sedimentological context, total organic carbon (TOC) contents and car-bon stable isotopes ($\delta^{13}C$) were analyzed across this unit that reaches in this sector more than 120 m thick.

TOC determined in 45 marly levels shows that the Coimbra Formation is locally very rich in organic matter, reaching up to 11.5 wt.%. In this dominated carbonate unit more than 20 levels are identified with TOC > 3 wt.%, highlighting the subunit F (~ 4 m) that shows several samples with TOC > 8 wt.%. This subunit is the thickest marly interval of the entire studied succession and contains an abundant ammonite record dated from *Denotatus* Subzone (top of *Obtusum* Zone). All of these sedimentary and geochemical characteristics suggest that subunit F reflects the main transgressive event recognized in the Coimbra Formation.

$\delta^{13}C$ was analyzed in 129 samples of bulk micritic sediments. $\delta^{13}C$ has a large variation, ranging from -3.74‰ to +2.71‰. The vertical variation of $\delta^{13}C$ shows a great dependence of facies and lithological units. The most pronounced negative excursion is observed in the organic-rich marly interval of subunit F, with values always below +0.44‰. Positive values, generally above +2‰, are observed in different parts of the succession, including the possible Obtusum-Oxynotum Zone boundary and in great part of the Oxynotum Zone, as evidenced in previous works.

Following the former studies in the overlying Água de Madeiros Formation (*Oxynotum* – base of *Jamesoni* Zone), the new data presented here confirm the organic-rich character of the Coimbra Formation. A $\delta^{13}C$ reference curve is now available for the entire Sinemurian carbonate record of the Lusitanian Basin, facilitating extrabasinal chemostratigraphic correlations.

MEDITERRANEAN OUTFLOW WATER AND CONTOURITE DEPOSITIONAL SYSTEMS OVER THE LAST 1.4 MA IN THE GULF OF CADIZ

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The Contourite Depositional Systems (CDS) in the Gulf of Cadiz are unique archives of the Mediterranean Outflow Water (MOW) variability since the Gibraltar gateway opening. These CDS have been generated by the upper and lower paths of the MOW, MUW and MLW respectively. These CDS have been studying with many different data based on high resolution and very high resolution seismic profiles and sedimentary cores. They have been also drilled during the IODP Expedition 339 (2011-2012). These drill sites offer a new data set over a longer period, allowing comparisons between recent and older climatic cycles, in sites both under the MUW and MLW cores.

This study provides preliminary results of a detailed sedimentological and facies analysis of different CDS in the Gulf of Cadiz over the last 1.4 Ma, using mainly grain size, natural gamma ray data, and XRF results from specific intervals. Downhole and core gamma ray data coupled to grain-size results provided a regional scale chronostratigraphic framework for the CDS contourite deposits and hiatuses at the regional scale. These long sedimentary records provide an overview of the behavior and circulation regime of the MOW over the large changes in climate and sea-level cyclicities and especially over two periods: the last climatic cycle MIS1-MIS2 and at the mid-Brunhes Event (MIS10-12) which is an analog of the last cycle.

The sedimentological and facies characteristics of contourite deposition over Pleistocene is controlled by a complex interaction of neo-tectonic activity, sea floor topography, sediment supply, downslope sediment transport and changes in bottom current flow and sediment transport. Two of the significant controlling factors on CDS are abrupt climate and sea-level changes over glacial and inter-glacial cycles.

DELAYED RESPONSE IN SEDIMENT CALIBRE DURING THE PETM IN NORTHERN SPAIN

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The Palaeocene-Eocene thermal maximum (PETM) represents a globally abrupt episode of global warming. This event is marked in the terrestrial and marine sedimentary record as a negative $\delta^{13}C$ excursion, which is concomitant with an increase in the amount and size of detrital material. However, the precise temporal relationship between the $\delta^{13}C$ marker horizon and the onset of increased detrital material is unknown. Detailed analysis of a terrestrial and marine section within the same sediment routing system suggests that the production and transport of detrital material from mountain catchments to these sites lags behind the negative $\delta^{13}C$ marker horizon by ca. 10-15 ka. A number of mechanisms could be responsible for this lag and these shall be discussed. Numerical modelling demonstrates that timescales of landscape response to a step change in precipitation can account for the observed lag. Crucially, the identification of a time lag between the carbon release event and the onset of increased sediment calibre tells us something fundamental about timescale of coupling between the climate and landscape system. If the anthropocene is indeed analogous to the rates of increase of global warming experienced during the PETM, our results indicate that we may have to wait 10 ka before its full effects are transmitted to the sedimentary record.

CHARACTERIZATION OF UPPER JURASSIC ORGANIC-MATTER-RICH CARBONATES IN THE GISSAR MOUNTAINS (TUBIEGATAN SECTION, UZBEKISTAN)

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New investigations are currently underway on the Middle-Upper Jurassic carbonates of the Gissar Mountains in the Amu-Darya Basin. Located in the southwest of the Gissar Mountains (SE Uzbekistan), the Tubiegatan section corresponds to 30-meter-thick limestone, overlain by 10-meter-thick dark limestone and marl interval. These dark, “black shale-type deposits” were also recognized in cores from the subsurface of the Amu-Darya Basin. The organic-rich deposits interval is precisely dated to the Luciaeformis and Schilli Subzones (Transversarium Zone, Middle Oxfordian) by ammonites. A transdisciplinary approach including sedimentology, organic matter characterization (Rock-Eval pyrolysis, palynofacies), bulk and clay mineralogy (XRD), carbon and oxygen isotopes of carbonate and organic fractions and whole rock trace-element geochemistry were used to elucidate the origin of these organic-rich deposits. Carbon-isotope curves were also established to help to correlate this interval with the partly contemporaneous carbonate platform. Both Tmax from Rock Eval analysis and clay mineral assemblages indicate a pronounced burial diagenesis (oil window). Despite this burial, paleoenvironmental and paleoclimatic can still be processed. Rock-Eval pyrolysis analyses performed on 65 samples show that TOC values range from 0 (peloidal grainstone) to 6 % on average for the tqhinly laminated black limestone. Interestingly, in this dark organic-rich deposits interval, higher TOC were measured in limestone (2% on average), while lower TOC values (0.5% on average) characterized marl and claystone, which is relatively unusual. Rock-Eval parameters (IH, IO) coupled to palynofacies observations (predominant amorphous organic matter) point to a probable marine, algal/microbial origin for the organic matter (Type II), with rare continental inputs mostly located in the upper part. Trace elements, as well as palynofacies and sedimentological observations demonstrate local O_2-depleted conditions promoting the preservation of organic matter. Such paleoenvironmental conditions may have supported bacterial mineralization processes related to anaerobic oxidation of methane, which would explain the very low $\delta^{13}C$ values (-5‰ to -12‰) measured in laminated facies. From the base of the organic-rich interval, a progressive decrease then disappearance of kaolinite, balanced by illite and illite/smectite mixed-layers (type R1), is observed. This coincides with the development of terrestrial phytoclasts inputs, suggesting a probable aridification in the Amu Darya Basin during the Middle/Late Oxfordian. Overall, the organic-rich deposits of Tubiegatan could record the onset of the disconnection of the Amu-Darya Basin from the open sea in the south, induced by compression and uplifts in the Afghan and Central Iranian blocks.

This disconnection, combined with a Tethys-wide aridification could have led to the progressive increase of evaporation and subsequent deposits on the carbonate platform, followed by the massive uppermost Jurassic evaporites (salt, anhydrite) of the Gaurdak Fm.

WAS THERE AN IBERIAN DESERT DURING THE MID-CRETACEOUS?

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Since about a decade several works developed the concept of desert environments at the origin of the thick sand deposits overlying coal units within the Escucha and Utrillas Formations (uppermost Aptian–uppermost Albian, Iberian Range, Eastern Spain). In the same while, silt-clay lenses, and even widely extended beds, interlayered in the stratigraphic succession yielded a palynoflora and a palaeoflora which are among the richest and most diversified in the world for this time span, and comprise several taxa of clearly hygrophyte character. This is why we present here a critical review, based on field observations, of the various sedimentologic clues put forward to claim an arid climate.

None of the sand-bodies studied showed a typical organization of aeolian deposit, whether it be sand sheets or dunes. Thus, largest structures, where clay drapes and intraclasts are frequent, are reinterpreted as those of subtidal bars (mostly ebb-dominated) and hydraulic dunes. Occasionally they contain quartz and quartzite dropstones, probably came there by stump-rafting from a fluvial watershed, as suggested by the proximity of silicified tree trunks. Pebbles and cobbles show no unequivocal clue of aeolian corrasion. In the western part, where they are abundant, their arrangement (especially segregation and lenticularity) is in some cases typical of wave-worked beach face deposits. In other places, well-sorted sands form upper flow regime plane-beds (swash-zone), while pebbles are concentrated in beach-step prisms.

Conspicuous ferralitic paleosols, where clays and feldspars are transformed into kaolinite clay matrix, are expression of emersion periods. Frequent sphaerosiderite in them is indicative of a late drowning phase preceding the next marine transgression. As for the rare occurrences of small gypsum rosettes, they can be attributed to a telogenetic origin, via the oxidation of iron sulphides present, not only in the underlying coals and their lateral facies, but also in the uniformly grey primary clay phase of the sandy units.

If compared with the "desert" hypothesis, all these elements are in better agreement with the regional palaeoenvironmental interpretations previously advanced, and with most of the current global palaeoclimatic inferences.

LATE HOLOCENE RECORD FROM THE LOIRE INCISED VALLEY (BAY OF BISCAY): INSIGHTS INTO REGIONAL VS GLOBAL CLIMATE FORCING FACTORS

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Well-dated sedimentary archives from the Fosse du Croisic, a Loire paleo-valley incised in the present day inner shelf of the Bay of Biscay (NE Atlantic), provide an exceptional high time resolution record of the Loire paleohydrology during the Late Holocene. A 5.4 m-long core (47°06'N2°33'W; water depth 58 m) was recovered during the DYNSEDIm^{2}015 cruise, organized by the SHOM (Service Hydrographique de la Marine Nationale). The impacts of global and regional climate forcing factors on the hydrological regime of the Loire River, and on depositional environments in the downstream river system, were investigated by sedimentological and benthic foraminiferal analyses (LPG-BIAF, Angers), X-ray imagery, XRF-major elements and ^{210}Pb profiles (EPOC, Bordeaux), and Total Organic Carbon content (Intechmer, Cherbourg).

During the last 2 600 years (cal BP), seven climatic periods were identified with an alternation between arid and humid prevailing climate conditions:

- Four arid periods were described: 2 600 – 2 400 cal BP; 1 7501 450 cal BP; 1 200 – 1 000 cal BP, interval at the transition between DACP (Dark Age Cold Period) and MCA (Medieval Climate Anomaly); 100 cal BPPresent, time-interval covering the period from the end of the LIA (Little Ice Age) to the MCW (Modern Climate Warming);
- Three humid periods were described: 2 400 – 1 750 cal BP, time-interval included in the RHP (Roman Humid Period); 1 450 – 1 200 cal BP, period synchronous with the DACP; 1 000 cal BP – 100 cal BP, the longest and most prominent humid period characterized by a first 300-year phase of transition linked with MCA, and a second 600-year phase with very humid conditions contemporaneous to the LIA. The timing of these humid periods is similar to that described across the Iberian Peninsula and in the Alps region, but concomitant with dry periods prevailing in Scandinavia.

The results suggest a strong control of the regional climate factors on the paleohydrology of the Loire and thus on the climatic conditions over its catchment area during the Late Holocene (e.g. NAO: North Atlantic Oscillation). Moreover, spectral analyses indicate that variations of sedimentary processes in the Loire river system are the result of a combination between long-term (~1 500 years) fluctuations of the NAO, and short-term (pluri-decadal to pluri-centennial) cyclicity of solar activity.

EVOLUTION OF BURIAL AND DIAGENESIS IN LIMESTONE-MARL ALTERNATIONS: INSIGHTS FROM TURBIDITES, INJECTITES AND FRACTURES INFILL (BLUE MARLS FORMATION INFERRED FROM SE BASIN, FRANCE)

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This study discusses the burial diagenetic evolution of limestone-marl alternations (LMA) from the apto-albian Blue Marls formation of Sisteron (SE France). Based on mineralogical, textural and stable isotope analysis of the limestone, marlstone, and some intercalated sandy turbidite beds of the hostrock, as well as clastic dykes injected in the stratigraphical pile, we propose a reconstruction of the burial depth, a cementation scheme, and the reconstruction of the pre-cementation isotope value of the limestone beds. The macroscale observation of the trace fossils highlights a differentiated compaction between the limestone (compaction ratio (t) of 2) and the marlstone (t = 5); the turbidite beds being nearly not compacted (t = 1.2). The reconstruction of the initial porosities of the carbonate mud and turbidite sand indicates that cementation occurred between 900 and 1100 m in depth, a burial that falls within the range of carbonate dissolution (chemical compaction). Subsequent dissolution of the carbonate in the marly layers, as indicated by the solution seams and the high compaction ratio, provides fluids for cementation of the limestone and clastic beds. From the carbon or oxygen isotope values of the different lithologies, a pattern is observed along the stratigraphic succession: the highest $\delta^{18}O$ values are associated to the marlstone (mean -3.4 ‰) close to that of the limestone that are more negative in the range of 0.5 to 1 ‰ (mean -3.9 ‰). The $\delta^{18}O$ values of the turbiditic beds are 1 ‰ more negative than the limestone ones. The most negative values correspond to the dykes (mean -6.3 ‰). Similar observation can be made with the $\delta^{13}C$, but over a more restricted domain (0.5 to 2 ‰). The homogeneous oxygen and carbon isotope composition of the dykes along the Vieux Bevons section and the similar isotope values for the dykes and the topmost turbidite show that the cementation of dykes and turbidites occurred by a single carbonate cement phase. Based on the contrast of permeability between the different facies, the turbidites and dykes may be considered as the main drains during the chemical compaction and thus their isotope record as the signature of the pervasive phase of carbonate cementation affecting limestone beds of the LMA during burial diagenesis. The proposed reconstitution of the pre-cementation oxygen isotope record of the limestone beds shows a small but significant contrast between the original value of mud that will become marl or limestone beds. The chemical compaction processes have increased significantly the contrast between the isotope signatures of marly and limy muds of the precursor sediment. The presence of the clastic facies in LMA confirmed the diagenetic origin of the oxygen isotope signature of the limy beds, bringing to conclusion that any climatic interpretation should be performed on the marlstone.

PREAND POST-CONSOLIDATED SEDIMENT DEFORMATIONS IN THE TRANSITIONAL TERRIGENEOUS SERIES (ZECHSTEIN/LOWER BUNTSANDSTEIN IN THE NORTH-SUDETIC SYNCLINORIUM

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The study area is located in North-Sudetic Basin in SE marginal parts of European Zechstein basin, where KGHM Polska Miedź S.A. holds a concession for documenting sediment-hosted copper deposit. During core logging one of the difficulties was to determine the boundary between Permian and Triassic sediments. A sandy-silty-argillaceous transitional succession is distinguished between Permian and Triassic deposits and is referred as a Top/Transitional Terrigeneous Series (PZt). A zone of preand post-consolidated sediment deformation was described within tempestites heterolithes. It turned out to be significantly helpful horizon in determining boundary between both systems.

In the course of this study the boundary between Zechstein and Buntsandstein was set in the uppermost part of heterolithic series. These are represented by alternated layers of grey white to grey green, fine to very fine grained quartz sandstones and red brown mudstones. In addition to the high structural variability, they are characterized primarily by the deformation of the original structure with features typical for soft sediment deformation, as well as brittle deformation and brecciation.

The zone of pre-and post-consolidated deformation structures has varied thickness from 2 m in N and NE up to 14 m in SW of the study area. In principle, the original structure of the sediment is more or less susceptible to the destruction or complete obliteration. Sometimes it comes to rebuild of the sediment structure due to plasticization or liquefaction. The predominant pre-consolidated sediment deformation structures occurring in the study area are: reversed density stratification (‘ba’), neptunian and clastic dykes, clastic diffusional cells, compacted desiccation (syneresis) cracks. If such structures form a correlation horizon on a larger area, they might be an indicator of seismic shocksseismites. Seismic activity of the research area occurring at the turn of the Permian and Triassic may be also confirmed by the occurrence of compacted cracks in a soft sediment. Within these structures redeposited sediments filled with clastic or mineral material are visible. If they present penetrative character, they may indicate the synsedimentary tectonic activity of the study area.

For post-consolidated deformations authors consider these phenomena, which are accompanied by the break of continuity of the sedimentary planes, relocation along newly created planes within the sediment or brittle failure (e.g. brecciation). These structures can be classified primarily as (micro)faults. There is no doubt that the horizon described at the boundary of the Permian and Triassic is correlated in the area ranging from a few kilometers to the south and a few tens of kilometers north of the border of the present structure of the Fore-Sudetic Block. The pre-consolidated sediment deformation structures have numerous features of seismites, however post-consolidated deformation structures raise more doubts about their origin and require more research.

MIXED SILICICLASTIC AND CARBONATE SHELF-MARGIN DEPOSITION IN THE JURASSIC AGADIR-ESSAOUIRA BASIN, MOROCCO: UNDERSTANDING THE EVOLUTION OF THE ATLANTIC MARGIN CARBONATE PLATFORMS

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The Agadir-Essaouira Basin records a complete Mesozoic succession, from the Triassic continental rift deposits to the Jurassic and Cretaceous marine post-rift deposits. The Jurassic outcrops expose the first post-rift deposits of the Central Atlantic margin and therefore the development of extensive carbonate platforms. Understanding the evolution of this basin will improve our appreciation on the controls of carbonate platform development along the Central Atlantic Margin during the Jurassic. This study presents the evolution of the carbonate platforms in the Agadir-Essaouira Basin from the Lower to Upper Jurassic.

Extensive basalt flows mark the transition from Triassic to Jurassic deposits in the Central Atlantic Province. They are overlain by Lower Lias fluvial red mudstones, siltstones and conglomerates. Above these fluvial deposits, sebkha and shoreface deposits mark the base of the transgression which established the first carbonate platform across the entire basin. Peritidal deposits including thick salt horizons alternating with dolomitic levels and stromatolites are progressively replaced by subtidal deposits towards the top of the formation. Offshore, the salt horizons were thicker and have been remobilised to form salt sheets and diapirs which shaped mini-basins during Middle Jurassic. The presence of fine siliciclastics in the peritidal and subtidal deposits varies depending on the location and the stratigraphic position, but implies a continuous influx of terrestrial material throughout the Lias. Middle Jurassic sedimentation was dominated by regressive siliciclastic deposits gradually developed in the East and South of the basin. The same interval in the NW of the basin shows facies dominated by dolomitic limestones, which indicates that the carbonate platform was still active during this period further offshore. After this regressive interval, siliciclastic influx stopped, and Callovian to Upper Oxfordian limestones record a major marine transgression throughout the entire basin.

During the Callovian, the transition from continental to marine is gradual and allowed the rapid establishment of a very extensive open marine carbonate platform. The Upper Callovian is marked by marls that are interpreted as a regional maximum flooding surface. The overlying Oxfordian deposits are dominated by coral reef deposits with extension of reef bodies varying from 10 m to several km. Coral reef growth and disappearance are related to local phenomena such as the growth of a salt anticline or siliciclastic influx. The Upper Oxfordian deposits record the disappearance of the reefs and a strong regression with the establishment of lagoonal deposits.

Coral reef geometries and units thicknesses vary quickly around the basin, locally they can be linked to salt tectonic. This control is difficult to quantify in the field but it has been demonstrated in coeval deposits in the Central High Atlas. Restricted siliciclastic inputs, possibly driven by hinterland tectonics, appear to have had a strong impact on the corals disappearance. The main recognised controls of the platform evolution are then the local salt tectonic and siliciclastic inputs linked with the regional structural movements of the basin and the variations of the eustatic level.

MASS-WASTING AND CURRENT PROCESSES ON THE DISTAL PORTION OF THE WEST FLORIDA PLATFORM

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The west Florida Platform that terminates at the Florida Escarpment is often taken as a modern example of a distally steepened ramp. Most previous studies attribute a major role to the Loop Current in the Gulf of Mexico for the sediment distribution on the distal ramp, although large-scale, gravity-controlled mass movements have been documented on seismic data. In 2012, RV Maria S. Merian (MSM 20-4) visited the distal portion of Florida platform at two locations. Combining high-resolution, multibeam bathymetry data acquired during the cruise and the large-scale bathymetry data GMRT-Background Grid downloaded from GeoMapApp document enormous submarine landslides on the ramp slope above the Florida Escarpment. The influence of the Loop Current that occasionally invades the distal ramp is much less obvious from the seafloor morphology. Instead, there is evidence of strong currents flowing down-ramp.

In the investigated area the distal part of the west Florida ramp dips with less than 0.5° to about the 400 m contour line. At this depth the inclination of the seafloor increases markedly to 57°, forming an approximately 20 km wide slope that stretches from the inclination break to the top of the escarpment. The morphology of the slope and escarpment differ from the central to the southern portion. In the northern area the gently dipping ramp terminates abruptly at an irregular cliff of 50 – 70 m height that runs across the study site for over 30 km. The terrace below the cliff and is littered with high relief blocks and boulders. At ~800 m water depth slope canyons start to incise the slope. At 900 m they are about 500 m wide and 40 m deep; downslope at ~1400 m they deepen and widen to ~650 m width and 70 m depth. In the southern area the shape of the slope is generally is concave. Here, the seascape is dominated by large cliffs and slide scars with block and boulders below the scars. Despite all these mass wasting features, the west Florida slope has little sediment cover. The sea floor consists of hardgrounds that are up to 10 myrs in age and colonized by deep-water fauna. Whatever sediment is present, is grain-rich, indicating winnowing of fines by ocean currents. These indications of current winnowing and non-deposition are at odds with the strength of the Loop Current. Velocities in the northern study site are approximately 0.5 m/s at the surface but at 400 m water depth the current is nearly stagnant. There are, however, clear indications for current flowing downslope, such as furrows on the gently dipping distal ramp and plunge pools below submarine cliffs. Therefore, sediment removal might be carried mostly by the off-shelf currents that like on Great Bahama Bank are density driven currents of high-salinity waters from the shallow-water areas.

INTEGRATING PROCESS MODELS IN SOURCE TO SINK ANALYSES: THE EUROSEDS TURBIDITY CURRENT SEDIMENT BUDGET ESTIMATOR APP

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A strength of the source-to-Sink approach has been that it made the ultimate simplification of the process of sediment transport, while still yielding robust and informative answers to geological problems. Sediment is simply distributed from the source to the sink, and the various depositional subsystems that are passed along the pathway act to extract a certain fraction of the available sediment budget. This may be counterintuitive when observed parallel to the development of process-based modelling efforts that seek increasingly more detailed and complex treatments of sediment transport. This attention to increasing complexity may therefore not be the path towards delivering a process-model of turbidity currents that can contribute to constraining sediment budget estimates in sedimentary system analyses.

Our aim is to package state-of-the-art knowledge on the dynamics of turbulent suspended sediment transport within a tool that relies solely on input of geological constraints such as basin configuration and characteristic feeder channel architectural dimensions. The result is a process-based turbidity current model that reconstructs the sediment budget transferred from the slope to basin floor fans over geological timescales.

The reconstructions are based on a dozen quantitative relations that together form a system describing suspended sediment transport in channelized turbidity currents. The necessary input constraints are based on simple and easily obtainable parameters from geological datasets such as seismic or well-logs, not on fluid dynamic considerations.

The outputs are twofold. Firstly, the app provides estimations of the velocity and concentration profiles of turbidity currents, and secondly, it supplies histograms of the system's total sediment budget. All that is required to derive the total budget is an estimation of flow recurrence, duration, and time intervals of geological activity. These inputs can be based on the user's understanding of their particular system, or on default values for system styles suggested in literature.

The simplicity of the model allows computation of 10's of thousands of turbidity currents in seconds. This makes the app suited to consider multitudes of scenarios, resulting in simple statistics such as min, max, best guess, median, 10^{th} and 90^{th} percentiles, and makes the app suitable to include in processbased predictive capabilities in stochastic modelling.

We apply the tool to a submarine channel deposit from the Cretaceous Tres Pasos Formation (Chile). This application shows that the shape of the probability distribution functions of the predicted sediment budgets depends on the confidence bounds of the geological model. Hence, the predictability of source-to-Sink transfer of sediment depends on the strength and confidence of the geological model, not on the uncertainties in hydraulics of sediment transfer.

LINKING AN EARLY TRIASSIC DELTA TO ANTECEDENT TOPOGRAPHY: SOURCE-TO-SINK STUDY OF THE SOUTHWESTERN BARENTS SEA MARGIN

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Present-day catchments adjacent to sedimentary basins may preserve geomorphic elements that have been active through long intervals of time. Relicts of ancient catchments in present-day landscapes may be investigated using mass-balance models and can give important information about upland landscape evolution and reservoir distribution in adjacent basins. However, such methods are in their infancy and often difficult to apply in deep-time settings due to later landscape modification.

The Southern Barents Sea Margin of N Norway and NW Russia is ideal for investigating source-toSink models, as it has been subject to minor tectonic activity since the Carboniferous, and large parts have eluded significant Quaternary glacial erosion. A zone close-to the present-day coast has likely acted as the boundary between basin and catchments since the Carboniferous. Around the Permian-Triassic transition, a large delta-system started to prograde from the same area as the present-day largest river in the area: the Tana River. The Tana River has long been interpreted to show features indicating that it was developed prior to present-day topography, and we perform a source-to-Sinkstudy of this ancient system in order to investigate potential linkages between present-day geomorphology and ancient deposits.

We investigate sediment load of the ancient delta using well, core, 2D-, and 3D-seismic data, and digital elevation models to investigate the geomorphology of the onshore catchment and surrounding areas. Our results imply that the present-day Tana catchment was formed close to the Permian-Triassic transition, and that the Triassic delta-system has much better reservoir properties compared to the rest of Triassic basin infill. This implies that landscapes may indeed preserve catchment geometries for extended periods of time, and demonstrate that source-to-Sink techniques can be instrumental in predicting extent and quality of subsurface reservoirs.

SEDIMENTOLOGY AND SEQUENCE STRATIGRAPHY OF PHOSPHATE-BEARING DEPOSITS ACROSS THE HIGH ATLAS OF MOROCCO

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The margins of the Moroccan High Atlas Mountains host phosphate-bearing sediments within marine-dominated series dated from latest-Cretaceous to Mid-Eocene. Fifteen sections have been logged on both southern and northern borders of the High Atlas, with the aim of constraining the basin evolution and the forcing parameters of phosphate accumulation.

Facies associations assigned the studied series to a shallow-waterplatform. Two major stratigraphic markers have been identified across the studied sections: i) a karstic surface above the uppermost Maastrichtian that witnesses platform emergence when the relative sea level fell down. ii) a lower Paleocene hardground surface or condensed section reflecting a period of maximum relative sea level rise and restriction of clastic inputs into the basin.

Phosphate particles occur mostly as granular pelletal phosphate, and less commonly as phosphatized vertebrate bones and teeth.

In the studied sections, phosphate accumulations correspond to two distinct modes: i) The most common corresponds to One-to-ten-meters-thick marls containing phosphate particles, above hardground or condensed interval. They correspond the base of regressive sequences; ii) Compacted sandstone phosphate horizon, immediately above a transgressive breccia over a karstic surface.

We present preliminary results of facies evolution and correlation across the basin.

DEPOSITIONAL CONDITIONS OF DYSODILES, UNCOMMON LACUSTRINE OIL SHALES FROM THE BARREMIAN OF LEBANON

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Dysodiles are organic rich paper shales described by Cordier in the middle of the 19th century. These oil shales are characterized by their richness in fossils and their important hydrocarbon potential.

Dysodiles were recognized in many localities from different ages in Lebanon. Despite their paleontological, paleoenvironmental, and petroleum interests, Lebanese dysodiles are not yet studied and remain unknown to most workers in Geosciences. The environmental conditions that led to the deposition of these layers are still largely unknown. We started recently to have interest in these layers after numerous discoveries of new outcrops in several regions in Lebanon. Our aim herein is to characterize the depositional conditions of dysodiles using sedimentology, palynology and organic geochemistry.

We focus our study on the Barremian dysodiles cropping-out within the so-called Grès de base (sensu Dubertret) or Chouf Formation (sensu Walley). This latter is represented by fluvio-deltaic sandy facies measuring from few meters to 300 meters. Dubertret considered it as mostly an azoic unit formed by the intense erosion of the Jordanian granites, drained by a large river crossing the country and gave it an obsolete "Neocomian" age. Recent studies give this formation a Lower Barremian age, and reveal an exceptional richness in continental fossils with all the new discoveries in the numerous Lebanese amber outcrops embedded in these sandstones. Volcanic flows and volcanoclastic sediments are intercalated in the Chouf Fm., but are a subordinate facies.

We herein investigate five sites of dysodiles, distributed from north to south Lebanon. All studied dysodile deposits are of limited extension, both in term of space (few km wide) and thickness (few meters). They are mostly found nearby volcanic altered rocks, or associated to cinerites, therefore a possible relation is suggested between the volcanism and the deposition of these peculiar paper shales.

New sedimentological and geochemical data on these potential source rocks are provided. Sedimentological characterization and detailed stratigraphic logs show the context of the dysodile deposits. Paleontological discoveries (insects, turtles, plants, ostracods, fresh water gastropods and fishes) demonstrate the lacustrine depositional environments, while geochemical analyses lead to assessing the nature and potentials of the source rocks.

The preliminary results show a mineral composition made of quartz and clay minerals, high C_{org} values (3 to 24%, 15.6% on average), and an excellent source rock potential (up to 220 kg HC/t rock) related to a Type I kerogen. Adding to this organic richness, the exceptionally well preserved fossils and the palynofacies analysis help in accurately reconstructing the lacustrine paleoenvironment prone to dysodile deposition.

Hence, these oil shales were deposited in small and shallow lakes, probably enriched by nearby volcanic activity supporting the primary algal and possibly bacterial production, and creating a favorable anoxic bottom water environment necessary for the preservation of the organic matter.

AN ACTIVE BIOGEOCHEMICAL SULPHUR CYCLE IN THE MARGINAL BASINS OF THE MEDITERRANEAN SEA DURING THE MEDITERRANEAN SALINITY CRISIS

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Large amounts of gypsum were deposited in the marginal basins of the Mediterranean Sea during the Messinian Salinity Crisis. These basins were hydrologically restricted with respect to the Mediterranean Sea. Hydrological restriction favours anoxia and the development of an active biogeochemical sulphur cycle. The microbial processes that catalyse the redox reactions of the sulphur cycle fractionate S and O isotopes of dissolved SO_4^{2-} in a characteristic way. Gypsum deposits derive their SO_4^{2-} ions from marginal basin waters and therefore have the potential to record the isotopic signature of the sulphur biogeochemical cycle. We looked for evidence of S-cycling in Messinian marginal basins by analysing the S ($\delta^{34}S_{SO_4^{2-}}$) and O ($\delta^{18}O_{SO_4^{2-}}$) stable isotope composition of gypsum deposits from Italy (Caltanisetta [CB] and Piedmont Basin [PB]) and Spain (Nijar [NB] and Sorbas [SB] basins). We found two distinct isotope signatures that suggest active sulphur cycling in all basins. In a first set of samples from PB, NB and SB, $\delta^{34}S_{SO_4^{2-}}$ and $\delta^{18}O_{SO_4^{2-}}$values co-evolve from values typical of gypsum precipitated from modern seawater ($\delta^{34}S$ = 21.7‰ CDT; $\delta^{18}O$ = 13.2‰ CDT) towards more positive values ($\delta^{34}S$ = 25.5‰ CDT; $\delta^{18}O$ = 15.4‰ CDT), reflecting the bio-utilisation of isotopically light SO_4^{2-} during sulphate reduction. In a second set of samples, gypsum is not enriched in ^{34}S, but is either enriched (16.0 < $\delta^{18}O_{SO_4^{2-}}$‰ CDT < 18.9; CB) or depleted (7.7 < $\delta^{18}O_{SO_4^{2-}}$‰ CDT < 13.2; PB) in 18O compared to modern marine gypsum.

Samples bearing ^{18}O-rich SO_4^{2-} (CB) contain isotopically enriched hydration water (2.5 < $\delta^{18}O_{GY\text{-}H_2O}$ ‰ SMOW < 5.5), while samples bearing ^{18}O-poor SO_4^{2-} (PB) contain isotopically depleted hydration water ($\delta^{18}O_{GY\text{-}H_2O}$ as low as -4 ‰ SMOW). We interpret these observations as indicating that H_2S produced by sulphate reduction is being re-oxidised, imparting the oxygen isotope composition of basin water to the newly-formed SO_4^{2-} ion. In addition, the lack of a $^{34}SO_4^{2-}$ enrichment in this second set of samples, indicates that re-oxidation of H_2S was a very efficient process, preventing loss of isotopically light H_2S from the system. We are currently applying a numerical model of the biogeochemical S-cycle with the aim of constraining the rates of sulphate reduction and sulphide oxidation, to get a quantitative understanding of these ancient basins impacted by biogeochemical sulphur cycling.

SR ISOTOPE COMPOSITION OF MODERN MOLLUSCS SHELLS: ARE THEY A TRUTHFUL PROXY OF SEAWATER COMPOSITION ?

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The strontium isotope ratio ($^{87}Sr/^{86}Sr$) of modern seawater is generally considered as homogeneous at the global scale because the residence time of this element is longer than the global ocean mixing duration. However, temporal variations in the relative contribution of main geochemical sources (i.e., continental weathering or hydrothermal inputs) modulate this isotopic ratio through geological times. Reconstructing the long-term fluctuations of seawater $^{87}Sr/^{86}Sr$ ratios is thus of prime importance for: 1) understanding the evolution of geochemical cycles in regard to global geodynamic or climate events, and 2) producing chimiostratigraphical reference curves allowing relative dating of any biological samples. Owing to their large spatio-temporal distribution and their relatively good preservation, shells of fossil molluscs and brachiopods have been widely investigated for their strontium isotope composition in a perspective of stratigraphic application. Nevertheless, these relative temporal calibrations are based on the postulate that the calcitic or aragonitic shells record the global $^{87}Sr/^{86}Sr$ oceanic composition without any isotopic fractionation process. Whereas studies have confirmed this assumption, others have recently shown that, in proximal marine environments, modern shells tend to slightly deviate from the global oceanic signature of 0.70916 by displaying higher $^{87}Sr/^{86}Sr$ values. In fact, most molluscs live in marine environments influenced by detrital and freshwater inputs, which could modify the isotopic composition of proximal marine water. Thus, ~50 Sr isotopic measurements of modern mollusc shells (bivalves, gastropods and cephalopods) have been acquired to decipher if they reflect that of seawater or a local signal specific to the site studied. Mollusc shells show heterogeneous $^{87}Sr/^{86}Sr$ values above and below the 0.709160 signature of seawater depicting fluvial inputs or groundwater contributions. Furthermore, oysters from the Oualidia lagoon (Morocco) have an $^{87}Sr/^{86}Sr$ value as low as 0.708931 arguing for the local influence of groundwater discharges from the karstic area of Oualidia.

MID TO LATE HOLOCENE PALEOENVIRONMENTAL STUDY OF GIALOVA LAGOON, SW PELOPONNESE, GREECE

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The coastal areas of Eastern Mediterranean have long been the subject of research, due to their rapid geomorphological changes, but also because of their archaeological interest. Our study is focused on a shallow coastal lagoon of Peloponnese, called Gialova Lagoon, which is located near the ancient city of Pylos and for several years attracts the scientific interest of archaeologist, geomorphologists as well as sedimentologists. The objectives of our study are the reconstruction of mid to late Holocene depositional environments of the area and the correlation of our data to already existed publications, in order to shed a light to the better understanding of coastal palaeoenvironmental changes. For our interpretation, an 8 m deep core was drilled and a multi proxy approach was carried out, including sedimentological (grain size analysis and moment measures, total organic carbon – TOC and total nitrogenTN), geochemical (XRF-scanning) and palaeontological (micro-and macro fauna) data. The chronological framework of the present study is based on five ^{14}C dating and an age depth model was calculated by using OxCal software. Based on previous studies (6 cores up to a maximum depth of 10 m) and a total number of twenty ^{14}C dates were reevaluated. The interpretation of the collected data, revealed a transition from a shallow marine environment (6500-5800 yr B.P.) to a brackish/lagoonal (5800-3300 yr B.P.) as well as a freshwater/marsh environment (3300 yr B.P. to present).

DATING LATE QUATERNARY VOLCANIC EVENTS USING HIGH RESOLUTION OXYGEN ISOTOPE STRATIGRAPHY FROM IODP DRILLING CORE U1397A (LESSER ANTILLES ARC)

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Data acquired during IODP 340 expedition (2012) have been used to further investigate eruptive activity along the Lesser Antilles arc, to better understand the mechanisms involved in both the transport and deposition of large volcanic debris avalanche deposits, and to assess the potential for volcanic hazards associated with these avalanches. Until now, the knowledge of the different processes involved in the island arc volcanism was mainly limited to the often incomplete onland geological records and to a few marine records covering the last 100 ka.

The Grenada Basin is a major depo-center for large submarine landslide deposits (SLD), volcanogenic turbidites, large pyroclastic flow deposits, and pelagic sediments. Here we focused on core U1397A (14°54.41'N, 61°25.35'W, 2482 m bsl) collected west of Martinique on a high topographic bound in order to avoid perturbation related to erosive SLD and to continuously characterize the regional eruptive history. Pelagic sediment intervals were sampled every 10 cm to reconstruct a high-resolution chronostratigraphic framework. Numerous mass-wasting deposits (MWD) and tephra layers are observed throughout the 261 m long sedimentary sequence (55% recovery). Oxygen isotope analyses produce higher resolution dating than biostratigraphy or paleomagnetism during the Pleistocene and are well-correlated to global and regional isotopic records at millennial to centennial timescales. Oxygen isotope analyses have been constrained by AMS ^{14}C radiocarbon dating to identify the magnitude of any hiatuses due to turbidites or tephra deposits within the sedimentary record since the late Pleistocene period. Normal sedimentation rate is relatively constant and high (24 cm. ka^{-1}) without turbidites and MWD (that are more frequent and thicker during glacial periods) throughout the record and until the base of the core estimated around 250 ka. Oxygen isotope measurements are more scarce for periods older than Marine Isotope Stage (MIS) 5 (around 130 ka) due to the occurrence of massive and thick volcaniclastic turbidites that could reflect more intense volcanic and/or seismic activity from the Dominica and Martinique islands. Nevertheless, older MIS may be identified based on regional and global isotopic records.

This study provides a more detailed and complete history of volcanic activity in the Lesser Antilles arc. This high-resolution chronostratigraphic approach needs to be performed at more distal sites (e.g. Hole U1399) to decipher the complex sedimentary records of large submarine landslides drilled for the first time during IODP 340 Expedition.

ALLUVIAL-FAN TERRACES AS STRAIN MARKERS FOR QUATERNARY CONTRACTILE DEFORMATION IN THE INTERIOR OF THE SOUTHERN CENTRAL ANDES: INTERMONTANE ALLUVIAL BASIN FILLS IN THE CALCHAQUÍ VALLEY OF THE EASTERN CORDILLERA (CACHI-PAYOGASTA AREA), NW ARGENTINA (25°03'S, 66°07'W)

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Intermontane basins in the Eastern Cordillera of the southern Central Andes in NW Argentina constitute outstanding natural laboratories and their sedimentary fills are excellent archives where the competing influences of tectonics and climate on sedimentation and landform evolution can be evaluated. These basins are located in the interior parts of the Andean orogen and straddle the eastern boundary of the high-elevation intra-orogenic Andean Plateau. To the east the basins are delimited by reverse-fault bounded mountain ranges that occur in the transition to the broken foreland. One of the largest intermontane basins is the N-S oriented Calchaqui Valley. The basin is bounded by E and W-dipping reverse faults, respectively, and it is characterized by deformed Tertiary strata that are unconformably overlain by Quaternary conglomerates that are part of coalesced alluvial fans. The northernmost sector of the valley narrows considerably and neotectonic activity in this sector of the basin has been thought to be associated with the range-bounding faults. However, recent remote sensing inspection and fieldwork have revealed that tectonic activity also affects the internal sectors of the basin. Here, we use the Quaternary sedimentary deposits and associated landforms, such as fluvial terraces and alluvial fans, as strain markers that unambiguously record protracted tectonic activity in this region that has migrated into the interior sectors of the basin.

Different Quaternary alluvial deposits in the region between Cachi and Payogasta (25°03'lat, 66°07'long) at successively lower elevations shed light on the history of Quaternary deposition, landform evolution and faulting. These alluvial deposits overlie or are faulted by metamorphic rocks of the ubiquitous Puncoviscana Formation and its metamorphic equivalents: The Quaternary units also cover rocks of the late Cretaceous-Paleogene Salta Group and the Tertiary Payogastilla Group. Three alluvial-fan levels involving downcutting and intermittent aggradation (Q1, Q2 and Q3) can be identified, each of them with characteristic conglomeratic composition and clast provenance. Virtually all of these geomorphic strain markers are affected by the effects Quaternary tectonic activity. Fault scarps, folds, unconformities, and cataclasized and tilted conglomerates characterize these landforms and their deposits. In addition, changes in paleocurrents and provenance, and convex longitudinal stream profiles unambiguously demonstrate the impact of Quaternary tectonic activity in the Calchaqui Valley. Importantly, this region broadly coincides with areas frequently impacted by destructive historical seismicity.

Taken together, available sedimentological and structural information as well as historical and instrumental seismicity data show that the northern sector of the Calchaquíes Valley has been actively deforming during the Quaternary. This emphasizes the need to perform additional systematic investigations of the characteristics of the Quaternary deposits and their tectonic overprint at regional scale. Both, conglomeratic gravels and their associated landforms constitute valuable strain mark-ers to achieve this goal and help understand the spatiotemporal evolution of tectonic processes in light of ongoing contraction.

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COMPOSITION AND ORIGIN OF THE CEMENTS FROM THE JUMILLA FAULT: INTERACTION BETWEEN SUB-AND SUPRASALT EXTENSIONAL DEFORMATION (EASTERN PREBETIC ZONE, SE SPAIN)

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In salt-influenced rift basins, the study of the relationship between faults and cements allows determining the different diagenetic stages and, therefore, the different fluid flow events linked with deformation. The present study is located in the Eastern Prebetic Zone (Southeastern Spain) where three main kinematic events have been established: 1) a broad extensional phase responsible for the generation of the South Iberian passive margin (from Permo-Triassic to Santonian); 2) the inversion of the passive margin during the Betic orogeny (Campanian to middle Miocene); and, 3) a transtensive stage with passive diapirism that controlled the deposition of the upper Miocene to Quaternary sediments.

The area of interest includes a Middle-Upper Jurassic succession unconformably overlaid by upper Miocene deposits. The structure is characterized by a suprasalt cover symmetrically folded and detached from the Iberian basement by the Upper Triassic evaporites. The Upper Jurassic host rock (Oxfordian-Kimmeridgian in age) is a grainstone of peloids with echinoderms, foraminifers, oncoliths, algae and molluscs with $\delta^{18}O$ values from -5.4 to -4.9‰ VPDB and $\delta^{13}C$ values from -1.3 to +0.3‰ VPDB. It is affected by NE-trending suprasalt faults dipping 47-68° to the SE and soled into the underlying evaporites. The supra-salt faults have associated breccias cemented by three calcite cements (Cc1 to Cc3) and manganese oxides, which precipitate between Cc2 and Cc3. Calcite cement Cc1 is characterized by a variable cathodoluminescence and $\delta^{18}O$ values between -9 and -6.7 ‰ VPDB and $\delta^{13}C$ values between -3.5 and -2.6‰ VPDB. After Cc1, a subsequent fault movement produced breccias and cataclasites formed by clasts of both the host rock and cement Cc1 cemented by Cc2. Calcite cements Cc2 and Cc3 are non-luminescent and have $\delta^{18}O$ values between -7 and -6 ‰ VPDB and $\delta^{13}C$ values between -9.8 and -4.2‰ VPDB. The manganese oxides display dendritic, botroidal and acicular habits and consist of: todorokite ($(Na,Ca,K,Ba,Sr)_{1-x}(Mn,Mg,Al)_6O_{12}\cdot 3$-$4H_2O$), birnesite ($MnO_2$), romanechite ($(Ba,H_2O)_2(Mn^{3+},Mn^{4+})_5O_{10}$) and aurorite ($(Mn,Ag,Ca)Mn_3O_7\cdot 3H_2O$).

During the Mesozoic extension, the fracturing, brecciation and cementation processes affecting the suprasalt cover can be related to successive stages of subsalt deformation interacting with the Upper Triassic evaporites: (1) Initial extension promoted the formation of suprasalt drape folds over the Jumilla subsalt fault deforming the Jurassic cover. As a result, the extensional system was coupled allowing the upwards propagation of the Jumilla Fault. The process zone at the tip of the fault formed the brecciation of the Upper Jurassic rocks. During this initial stage, cement Cc1 precipitated from formation waters probably interacted with the underlying Upper Triassic evaporites. (2) During further upward propagation and development of the NE-trending suprasalt faults, cement Cc1 was reworked in breccias and cataclasites and the system opened to meteoric fluids precipitating cements Cc2 and Cc3. The precipitation of manganese oxides between Cc2 and Cc3 meteoric calcite cements could be controlled by a change in the redox conditions of the meteoric fluid.

SEDIMENTARY ANALYSIS AND CONTROLS ON THE STRATIGRAPHIC DEVELOPMENT OF TRIASSIC SERIES OF MOHAMMEDIA-BENSLIMANE-ELGARA-BERRECHID BASIN (WESTERN MESETA, MOROCCO)

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The Mohammedia-Benslimane-ElGara-Berrechid Triassic basin is located at the Moroccan coastal Meseta. This basin is in the form of a rift, initiated by the reactivation of pre-existing faults in the hercynian basement, giving rise to a series of half-grabens oriented NE-SW in the Lower Mesozoic.

This work presents detailed analysis of the outcrop and cores data to investigate sedimentological and paleoenvironmental evolution during Triassic. It is based on the nature, size of the components and sedimentary structures. We were able to identify tirtheen facies types and eight architectural elements in the basin, represented by purple and red brick detrital deposits. Facies evolve from massive or laminated conglomerates with erosive bases, or massive conglomerates sheet flood type, to sandstone medium to very fine with planar crossbeds, and siltstones and mudstones showing the levels of mottling. These later are interspersed with centimetric to metric levels of gypsum and halite, the entirety is covered by triassic basalts. This study has shown an important palaeoenvironmental evolution that begins with an alluvial fan environment up to a braided river environment that becomes anastomosed later. At the end, the system moved up to a coastal plain environment characterized by very fine and evaporitic deposits resulting from an installation of playa and also lagoonal environments.

This sedimentary analysis showed that facies are typical of a rift continental basin flooded by seawater from the Tethys and the Proto-atlantic incursions. The fluvial to playa and lagoons transition was due to a decrease in source area relief related to a decline in regional tectonic activity. The sedimentary accumulation was controlled by several allocyclic factors such as tectonics and the likely climate change responsible for the evaporites accumulation and other controlling factors represented by the general variation of the base level.

PULSED DRYING OF THE HELMAND BASIN, AFGHANISTAN: INSIGHTS FROM HIGH-RESOLUTION REMOTE SENSING OF THE GEOMORPHOLOGY

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Advances in using remotely-sensed data to understand surface processes on other planets in our Solar System has led to an upsurge in studies of tectonic geomorphology in remote and inaccessible areas on Earth where fieldwork is problematic. The Helmand Basin in southern Afghanistan is a prime example of such a location, having been a zone of active conflict since the 1970s. The associated lack of field access has meant that our geologic knowledge of the region is limited.

The Helmand Basin is a structurally enclosed region that defines a large (310,000 km^2) endorheicly-drained basin within a hyperarid climate. It is primarily fed by the Helmand River, which drains the western parts of the Hindu Kush Mountains and flows into the Sistan Depression on the western edge of the Basin. Despite the hyperarid climate, the Sistan Depression contains numerous shallow lakes, which host important agricultural and wetland areas with a long history of human habitation. However, fluctuations in the climate in the past century have led to regional droughts and conflict with neighbouring countries. Further back in time, the rise and fall of Bronze Age settlements in the region have been linked to changes in the course of the Helmand River and fluctuating lake levels.

This project uses a collection of high-resolution LiDAR topographic data from the Helmand region to reconstruct the large-scale geomorphologic evolution of the Helmand Basin. Our analysis suggests that the Basin once hosted a large distributary fluvial system that terminated into a great lake that had an area of >50,000 km^2. Over the Quaternary, the Basin experienced a progressive step-like drying up of the climate with an associated decrease in lake level and surface area. The pulsed lowering of the lake level at the base of the Helmand River, combined with drying of the climate, led to stepped lowering of the fluvial profile through time. This created a staircase of terraces on the northern margin of the Helmand River and a succession of deltas that progressively propagated into the Sistan Depression. These fluctuations in the fluvial system can be correlated to glacial cycles in the Quaternary and within the Holocene, may be a major cause of the decline of Bronze Age settlements in the region.

REGIONAL CONTROLS ON WATER TABLE LEVELS IN THE NORTHERN ATACAMA DESERT; IMPLICATIONS FOR SUPERGENE ENRICHMENT

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The Atacama Desert of Northern Chile hosts some of the largest supergene-enriched porphyry copper deposits in the world. Over time, both changes in precipitation and fluctuations in the depth of the water table are known to have been important controls on the supergene enrichment process. As the paleoclimate of the region becomes increasingly well understood, it is clear that whilst the climate has been predominantly hyperarid since the Oligocene, this hyperaridity has been punctuated by relatively more humid (but still arid) phases. In contrast, relative drops in the depth of water table across the Northern Atacama are still poorly constrained and vary from between < 200 m to > 1000 m within the same region and over the same time period. Due to the hyperarid climate of the Atacama region, there is exceptional preservation of relict landscapes across a wide (300 km) geographic area spanning geological (up to 20 Ma) timescales. In this study we use relict fluvial landforms, including peneplains, river terraces and alluvial fans as archives to reconstruct regional changes in water-table depth across the Northern Atacama Desert since the Miocene. The area of study includes regions that are characterised by two distinctly different terminal base levels (endoreic and exoreic), differing precipitation availability and a range of drainage areas. By reconstructing regional paleo-fluvial profiles we can assess the interaction between climatically-driven increases in sediment supply and fluvial discharge and changes in the terminal base level over a wide area of a tectonically erosive landscape. The results are used to constrain the main controls on changes in the relative depth of the regional water table within the Northern Atacama region, showing that relatively minor changes in relative water table fall are favorable for supergene enrichment in hyperarid to arid regions.

TUBULAR MICROPOROSITY IN FOSSIL MICROBIALITES OF THE MAQUINCHAO BASIN (ARGENTINA)

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Microbialites are defined as “organosedimentary” structures, resulting from the interaction between environmental and microbial factors. The two dominant fabrics leading to their formation are trapping and binding and/or precipitation of minerals linked to microbial processes. In the last years, extensive research has been carried out aiming to better understand the microbe-mineral interaction, the relationship between environmental conditions and macroscopic and microscopic structures of living microbialites and their preservation in the fossil record. Thus, studying these different aspects can provide key information on the prevailing environmental conditions during the formation of fossil microbialites.

The Maquinchao Basin in northeastern Patagonia (Argentina) provides an outstanding research area encompassing different types of microbialites such as fossil stromatolites, carbonate laminated crusts and living microbial mats. Fossil stromatolites are found in continuous and extensive banks outcropping mostly along the Maquinchao River or as distinct buildups. Carbonate crusts and living microbial mats are found at the riverbed, in dry and active ponds of the modern Maquinchao River, respectively.

Preliminary results comprise field observations including digital outcrop modeling using SfM-MVS photogrammetry and dGPS surveys-reconstruction using multi-images, light microscopy and SEM inspection of selected samples along with EDX and XRD analyses. The different outcrops are located at a constant elevation of 840 m, a higher altitude than the actual riverbed of the Maquinchao River. The field examination of fossil stromatolites reveals various types of structures linked to their stage of preservation/erosion. Domal columnar-like constructions are very well preserved whereas those specimens with only the outer part as well as a visible nucleus are less well preserved and appear to have suffered major erosion. These structures are often embedded within millimeter-sized particles resulting from the erosion of larger buildups. Mineralogical analyses on selected samples show a dominance of low Mg-calcite, as well as the presence of clay especially in the fossil microbialites. Three-dimensional microscopic examination of selected samples using multi-scaled X-ray CT-scanning techniques (X-ray tomography) reveals the presence of a very fine porosity in all three types of microbialites present in the Maquinchao Basin. The shape of this porosity is elongate/tubular with a diameter ranging between 5 and 7 micrometers. These preliminary results indicate very similar structures in both fossil and modern carbonate crusts pointing towards comparable formation processes. Moreover, the described small porosity is difficult to visualize without high-resolution techniques but fundamental for understanding the internal structure of these fossil microbialites as well as their degree and stage of erosion.

Combining the field observations, image analyses, sedimentary petrography and 3D tomography with geochemical data will contribute to develop a model of formation and preservation of both fossil and modern microbialites that can be applied to similar build ups at different geographical and temporal scales.

AUTHIGENESIS AND SEDIMENTARY CONDENSATION

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Most marine authigenic minerals form in sediments, which are subjected to condensation. Condensation processes lead to the formation of well individualized, extremely thin (< 1 m) beds, which were accumulated during extremely long time periods (> 100 ky), and which experienced authigenesis and the precipitation of glaucony, verdine, phosphate, iron and manganese oxyhydroxides, iron sulfide, carbonate and/or silica. They usually show complex internal stratigraphies, which result from an interplay of sediment accumulation, halts in sedimentation, sediment winnowing, erosion, reworking and bypass. They may include amalgamated faunas of different origin and age. Hardgrounds may be part of condensed beds and may embody strongly condensed beds by themselves. Sedimentary condensation is the result of a hydrodynamically active depositional regime, in which sediment accumulation, winnowing, erosion, reworking and bypass are processes, which alternate as a function of changes in the location and intensity of currents, and/ or as the result of episodic high-energy events engendered by storms and gravity flow.

Sedimentary condensation has been and still is a widespread phenomenon in past and present-day oceans. The present-day distribution of glaucony and verdine-rich sediments on shelves and upper slopes, phosphate-rich sediments and phosphorite on outer shelves and upper slopes, ferromanganese crusts on slopes, seamounts and submarine plateaus, and ferromanganese nodules on abyssal seafloors is a good indication of the importance of condensation processes today. In the past, we may add the occurrence of oolitic ironstone, carbonate hardgrounds, and eventually also silica layers in banded iron formations as indicators of the importance of condensation processes. Besides their economic value, condensed sediments are useful both as a carrier of geochemical proxies of paleoceanographic and paleoenvironmental change, as well as the product of episodes of paleoceanographic and paleoenvironmental change themselves.

TIGHT CHALK: HOW DO SEDIMENTOLOGY AND DIAGENESIS INFLUENCE MICROTEXTURE? HOW DOES MICROTEXTURE CONTROL RESERVOIR PROPERTIES?

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Since the discovery of the Ekofisk chalk hydrocarbon reservoir in the North Sea in the 1960s, porous reservoir chalk has been extensively studied. Only recently, there has been an increasing interest in understanding low reservoir-quality or tight chalks. Defined by a permeability lower then 0.2 mD, they may act as seals or form potential unconventional reservoirs. In order to better understand their characteristics, an integrated petrographical, petrophysical and geomechanical study was carried out on a set of 65 samples from NW-Europe outcrops. The dataset gathered covers a broad spectrum of values regarding petrophysical (e.g. porosities from 9 to 45%) and geomechanical properties (e.g: strengths from 3 to 50 MPa). The key parameter defining chalk intrinsic properties is its microtexture. Tight chalks encompass different lithotypes, but the main factors controlling microtexture are the non-carbonate content and degree of cementation. The respective influence of the depositional setting (e.g. detrital input) and diagenesis (eogenesis and mesogenesis) on the microtexture are unravelled. FIB-SEM analyses on 3 distinct samples (micritic, argillaceous and cemented chalk) show how these parameters modify porous network. The link between the observed porous network and the petrophysical and geomechanical properties of the samples was investigated. High degree of cementation and non carbonate content result in lower poroperm values. Cementation was proven to increase chalk strength and brittleness. Moreover, high clay content significantly reduces permeability and increases the rock plasticity.

UNDERSTANDING FLUID-FLOW DURING TECTONIC REACTIVATION: AN EXAMPLE FROM THE FLAMBOROUGH HEAD CHALK OUTCROP (UK)

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Flamborough Head chalks are located at the termination of E-W and N-S trending fault systems along theYorkshire coast (UK). Rock deformation is mainly expressed in Selwicks Bay where two faults, with displacements up to 20 m, are exposed and a high density of calcite vein swarms is observed. The main fault is characterized by an E-W fault damage zone composed in its center of a large calcite cemented hydraulic breccia. Cross-cutting relationships allowed to differentiate three vein generations: a network of thin pseudo-parallel veins perpendicular to the stratigraphy (Group I), hydraulic breccia with typical puzzle structure of chalk pieces including crack and seals (Group II), and a third generation of calcite veins crosscutting the two previous generations (Group III). Selective sampling was performed on these three sets for petrographic observations (optical and cathodoluminescence microscopy) and for geochemical analysis including stable isotopes measurements ($\delta^{13}C$ and $\delta^{18}O$, Sr isotopes) and ICPOES analyses for trace elements quantification. Geochemical analyses revealed that all 3 generations have the same chemical signature and reflect successive pulses from the same fluid source. Strontium isotope analyses show that veins reached $^{87}Sr/^{86}Sr$ ratios up to 7.11 while ratios of the chalk matrix equals 7.707. The latter is in agreement with the signature of Late Cretaceous seawater. These results indicate that the fluid originated from an external source, and reflect an open system. The radiogenic Sr-isotope ratios, combined with low iron concentration (Fe < 400 ppm) suggest fluids migrated through sandy deposits. Fluid inclusion salinities determined by microthermometry range from 0 to 12 wt% NaCl equiv. with a dominant meteoric water signal. Meteoric fluids were thus possibly stored in an underlying confined sandstone aquifer and could be remobilized due to Early Cenozoic tectonic activity. The wide range of salinities could result from mixing of the meteoric fluid with a more saline fluid or from the dissolution of salts in the subsurface. In addition to the understanding of the local paragenetic evolution of the Flamborough Head chalks, this study offers an insight into how fluid flows and mineralizes along fault zones (e.g. formation of hydraulic breccia). This may help understand fault zones behavior in subsurface tight chalk deposits.

ARE REE A GOOD TOOL FOR RECORDING PALAEO-REDOX CONDITIONS? EXAMPLE OF THE OAE2 ON THE NW AFRICAN MARGIN

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Upper Cenomanian-Lower Turonian carbonates from the Preafrican Trough (South Morocco) and Agadir Basin contain biological (benthic and planktonic organisms) and chemical markers (redox sensitive trace metals) illustrating a temporal gap in the occurrence of Oceanic Anoxic Event # 2 between the Atlantic Ocean and shallow water areas on the NW African margin. We make use of three contrasting sections corresponding to environments ranging from shallow water (Ziz, Agadir) to mid-ramp (Goulmima) to study the REE contents of these carbonates. We combine a comprehensive biological and sedimentary dataset withtrace metal geochemistry to compare these two types of proxies, which allows us to discuss the ability of REE patterns to record OAEs in carbonate sediments. Our REE data show typical seawater patterns and negative Ce/Ce* anomalies (Goulmima 0.62 +/-0.12, Ziz 0.81+/-0.12, Agadir 0.8 +/-0.01), which seems to indicate the persistence of oxic conditions, in contradiction with other chemical (U/Al, V/Al and Mo/Al) and biological markers (Buliminidae). To resolve this paradox, we use a geochemical model to reproduce the REE patterns observed in seawater, especially the Ce anomalies for presumed chemical conditions of the cenomanian-turonian seawater. There is a satisfactory agreement between measured and calculated REE values for the three studied sections, and, notably, this allows us to distinguish Cenomanian and Turonian water masses. Taking all these geochemical data together, we suggest that the Cenomanian-Turonian stratigraphic interval in the Preafrican Trough and Agadir Basin records a change of water mass during a transgressive event in an upwelling context. The dissolved oxygen levels of waters are not straightforwardly recorded in the trace metal concentrations of carbonates. Nevertheless, these data can be deconvoluted, provided the saturation state of seawater and the role of particles are taken into account. We propose that even if the negative cerium anomalies in carbonates are classically correlated with dissolved oxygen concentration, it is also, and maybe strongly, dependent on particle concentration and water mass circulation. This explains why several proxies are required to reconstruct the paleo-redox conditions in carbonate facies.

CARBONATE SLOPE MORPHOLOGY REVEALING DEEP-SEA SEDIMENT TRANSFER IN LITTLE BAHAMA BANK, BAHAMAS

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The first leg of the CARAMBAE 2 cruise off the Bahamas occurred in December 2016 on the R/V l'Atalante. New high-quality multibeam data acquired during this mission depict the area located between Little Bahama Bank (LBB, Bahamas) and Blake Plateau (BP). The survey details the morphology of a giant 150 km-long submarine canyon, the Great Abaco Canyon (GAC) and its main characteristics. The canyon axis runs parallel to the margin. Its head does not apparently represent the main source of material. The sediments supplied through the LBB canyon system does not reach this area which only shows erosion lineaments related to the pathway of currents flowing along the seafloor and restricted failure scars. Most of the supply comes from the canyon flanks. In the north, tributary canyons drain the contourite deposits forming large flat plateaus above the drowned carbonate platform of the BP. These contourite plateaus are subjected to translational slides moving towards the northern edge of the canyon forming a dissymmetric debris accumulation along the toe of the north canyon edge. Another sources of sediment are two large tributaries connecting directly the LBB upper slope to the GAC. Sub bottom seismic profiles suggest the presence of a turbiditic levee on the tributary canyon sides and inferred turbiditic activity. The transition from the Blake Plateau to the North Atlantic Abyssal plain occurs through a series of giant (several hundred of meters thick) chutes often associated with plunge pools. The most important one is underlined by an abrupt change of slope in the canyon thalweg. The last one leads to the opening towards the abyssal plain. Along the Abyssal plain, a 200-m-thick lobe develops. Its size is unbalanced with the size of the Great Abaco Canyon incision, reflecting probably the pirating by deep-sea current belonging to the thermohaline circulation, of the finegrained particles reaching the canyon mouth. Little Abaco Canyon (LAC) shows morphologic similarities with GAC but at a smaller size (75-km-long). However, the LAC seems more active in terms of sediment transport. Small canyons draining the easternmost part of LBB and discharging in LAC show lobate morphologies with fresh sedimentary structures (sediment waves) suggesting recent sedimentary processes. These structures are made of clean carbonate sand with shallow water organisms indicating a direct supply from the carbonate platform edge. The plunge pools in the two canyons can reach 250 meters in depth. They are located between 3.500 and 4.500 meters deep. Although plunge pools are frequent in siliciclastic environment, both in continental and marine context, it is the first time that such large elements are observed. These Bahamian plunge pools are 5 to 10 times bigger than the plunge pools observed in the Niagara Falls. In term of size, the GAC compares to the largest canyons in siliciclastic environments. Its originality comes from the fact it is only supplied by carbonate sources. These two canyons present the same axis as the Blake-Bahama fracture zone which represents a transform fault linked to the mid-oceanic ridge.

DETERMINATION OF PALAEOPRODUCTIVITY USING HYDROGEN INDEX AS A PROXY

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There has been much debate regarding the fate of organic matter (OM) during its transition to the sea floor, and about the quantification of OM remineralisation and preservation within subaqueous sediments. To improve our understanding of the global carbon cycle as well as the impact of anthropogenic contributions to this cycle, advancing our knowledge of carbon mineralisation in the oceans is required. In light of this, comprehension of the mechanisms controlling the fate of carbon within the oceans is of significance.

In order to quantify the preservation of OM in marine sediments it is necessary to understand the origin and decomposition of the organic material. Essentially two areas provide the organic input found within the pelagic environment, the autochthonously produced material and material transported from terrestrial environments. Many authors distinguish between types of organic matter through classification such as labile or more reactive OM and refractory or less reactive OM. Throughout this study OM is classified as labile and refractive only, with the two types being modelled with different decay rate constants (k) simulating their distinctive remineralisation processes.

Generally, models use palaeo-water depth as the main parameter through which the degradation of OM is characterised, however these models rely on input parameters which are difficult to obtain with any precision particularly for the geological past. This issue is eliminated in this study which utilises an alternative model to quantify the decay of organic matter in the water column, using hydrogen index in combination with biological degradation rates to produce a quantitative estimate of initial production from measured deposit values. Data from different depositional environments in conjunction with degradation rate constants appropriate for the environment of interest are used to back calculate palaeoproductivity. The data sets used were collected from literature, with hydrogen index measurements taken from recent sediments deposited during the Holocene. Likewise, literature data for laboratory derived rate constants, which measure k values for both the major components in addition to whole particulate organic matter, are used in this study.

RESERVOIR DESCRIPTION AND THE STUDY OF RESIDUAL OIL DISTRIBUTION LAW FOR MIDDLE S36-10 IN BLOCK PU67

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Based on the study of Middle S36-10 in Block Pu67 reservoir, the reservoir description, reservoir dynamic analysis, reservoir engineering and numerical simulation are integratedly applied. According to reservoir characteristics of Middle S36-10 in Block Pu67 reservoir, accurate correlation of flow unit, structural interpretation combined with borehole seismic materials, sedimentary microfacies analysis, diagenesis of reservoir and fracture characteristics, studies of the heterogeneity and sensibility of reservoir, the fine geological model of oil reservoir are established. Through in-house tests, dynamic analysis and numerical simulation, the distribution law of residual oil is studied. Major researches of this paper include:

1. The sedimentary microfacies study shows Middle S36-10 in Block Pu67 is submarine fan sedimentation. The main sedimentary facies is middle fan front to fan front. The microfacies include water channel, shallow channel, sand sheet, slump deposit and deep lake-half deep lake deposit. The main reservoir rock is water channel, then the sand sheet, others are less.

2. Diagenesis study shows middle S36-10 sand member was experienced compaction, cementation and erosion after deposition. While now displacement recememtation occurred so as to make porous structure weak.

3. According to requirements of reservoir development, 27 flow blocks are divided. In the 3 kinds of flow blocks that are sorted, there are 9 flow blocks of sort I, 8 of sort II and 10 of sort III.

4. The accuracy of understanding reservoir structure is obviously improved. So it is clear to determine structure pattern and fault spreading. It is thought that Pu 67 fault plays an important role for controlling the structural development of block Pu 67 and its petroleum accumulation. There are 5 sub growth faults developed in block Pu 67.

5. Study has been done on oil displacement mechanism of low percolation reservoirs with deep layer. The research results indicate flooding rate and injection pressure have unconspicuous effect on formation of residual oil. The heterogeneity of reservoir pore texture is a major cause of displacement efficiency.

6. Combining dynamic analysis and numerical modeling, qualitative analysis and quantitative analysis to study residual oil distribution of the reservoir, the result shows that plane residual oil distributes around waterflooded area, elastic development area, and uncompleted injection and production area. Some major layer (61.3, 82.3.4 etc) are seriously waterflooded, the residual oil distributes scatter.

The achievements of this paper have been used in developing the residual oil in Middle S36-10 in Block Pu67 reservoir. The field implication also proved its reliability, good application, maneuverable measures and economic use. Meanwhile, the research method of residual oil distribution and developing techniques of reservoirs with deep layer, low percolation is of certain guiding importance for development of the assemble reservoir.

THE CHARACTERISTICS OF DONGHE SANDSTONE RESERVOIR AND THE OCCURRENCE STATE OF REMAINING OIL BASED ON MICRO CT AND NMR

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The Donghe Sandstone was broadly deposited in the early stage of the marine transgression, which formed the biggest marine clastic rock reservoir in China. The reservoir is in the middle-late development period. Tazhong4, Hade and Donghe1 are the main well areas in Donghe Sandstone reservoir. They have similar features of petrology, physical property and percolation property because they are all shore deposition. But the different depositional setting caused the differences of reservoir in well areas and parasequence sets. According to the observation of sections, mercury injection experiment and physical property measurement data, Donghe Sandstone reservoir can be divided into 6 kinds of pore-throat structure. They are big poremiddle throat structure, big pore-thin throat structure, middle pore-middle throat structure, middle pore-thin throat structure, small pore-thin throat structure and small pore-tiny throat structure. Combining the change rule after water flooding, these pore-throat structure can compose into 3 kinds of subreservoir. The reservoir qualities of type A becomes better after water flooding. The qualities of type B almost have no changes with water flooding. The type C shows an adverse trend of type A. Based on the 3 kinds of reservoir, selecting out 3 rock samples for the physical simulation experiment. During the experiment, CT scanning the rock samples in the saturated oil state, low water flooded state and strong water flooded state. Addition to the 3 states, nuclear magnetic resonance experiment should add a measure in the saturated water state at the beginning. The 3D remaining oil digital model and 2D NMR spectrum can be got through processing experiment data. Based on the remaining oil's geometrical morphology showed by digital model and occurrence place showed by NMR spectrum, the occurrence state of remaining oil can be divided into 5 types, membrane flow, dropwise flow, columnar flow, porous flow and tufted flow. From the point of view of the change of the occurrence state, the forming of remaining oil is a process of oil-continuous phase transforming to oiluncontinuous phase. In this process, the big tufted flow is broken up to small tufted flow, porous flow and a small amount of membrane flow, dropwise flow, columnar flow. Water phase spread unevenly, caused by heterogeneity of pore-throat structure, is the primary cause of remaining oil in Donghe Sandstone.

A NEW EXPLORATION DIRECTION: RESIDUAL OIL ZONE IN THE TARIM BASIN, NW CHINA

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The Donghe Sandstone was broadly deposited in the early stage of the marine transgression, in which the anticline reservoir inside is the main pay zone in Carboniferous Tarim basin. Residual oil zone, adjacent the major reservoir, will become the key to increase in oil reserve and production of marine facies clastic rock reservoir. However, evidence, such as oil-bearing core and hydrocarbon inclusion, indicates that there exists a good deal of residual oil in the residual oil zone, whose favorable zones can be divided into three categories. 1) Bottom water residual oil zone (bwROZ), which was once located above the paleo oil-water cantact (OWC). Because of the damage to the reservoir seal part of the hydrocarbon escaped and the others could still be preserved in bw ROZ; 2) Transition zone(TZ), which is the area between the OWC before exploition and the current OWC. 3) Accumulation conducting zone(ACZ), can capture a considerable volume of petroleum along the migration path. And there are four kinds of residual oil areas that are able to preserve hydrocarbon in bw ROZ, TZ and ACZ: 1) Microstructures, which exist below stable seepage barriers, can preserve microstructure reservoir; 2) The surrounding areas of low angle inclined interlayer, can preserve sphenoid remaining oil because of shelter effect; 3) The region with poor physical property, can preserve mass remaining oil due to strong seepage resistance; 4) Most reservoirs with fair physical property, which are oil wet, can capture a certain amount of oil. As a result, four classes of favorable areas in three kinds of residual oil zones control current residual oil pattern. As for Tazhong 4 Donghe Sandstone reservoir, paleo integrity reservoir has undergone the destruction due to faults translocation, and then formed a largescale bwROZ, whose OIP is about 15MMB. Hadexun Donghe Sandstone reservoir is a secondary reservoir, whose petroleum came from northwestern paleo oil reservoir through Donghe Sandstone. A good deal of hydrocarbon has been preserved in ACZ, whose OIP is about 18MMB.

RESEARCH ON SEDIMENTARY MODEL OF MODERN DELTA SEDIMENT IN PO YANG LAKE

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PoYang Lake is the largest freshwater lake in China, Ganjiang River, Fuhe River, Raohe River, and other rivers feeding into it. Controlled by the water system around, a number of different types of modern delta sedimentary lobates have been formed. Based on the analysis of modern sedimentary study and satellite images, we recognize 4 secondary sedimentary units: distributary channel, distributary channel flank, tributary bay and lake water and two delta types are determined: lobate and dendritic.

The lobate delta is developed in lower contained vacuity, gentle slope terrain and shallow water open environment, and the shape of the whole delta is a lobe. Ganjiang delta is a typical lobate delta, its landform elevation difference is less than 3 m. The dendritic delta is developed in a relatively higher contained vacuity with abundant source supply and limited lake basin. It is mainly controlled by fluvial action, and the delta shape is a branch, belonging to the constructive delta. The Xihe delta is a typical dendritic delta, and its landform elevation difference is between 4 m and 6 m.

Underwater distributary channel, underwater distributary channel flank, sheet sand and tributary bay are developed in the modern deltas in PoYang Lake. The underwater distributary channel is the main microface and it controls the shape and size of the other microfacies. The underwater distributary channel in the lobate delta extends radially from land to lake like vein, which gradually narrows along the flow direction, and branches and gathers constantly. The shape of the underwater distributary channel in dendritic delta is branch, and the extended distance of the underwater distributary is generally distant.

Based on the Po Yang Lake modern delta sedimentary data, we established the quantitative model of underwater distributary channel and reveal the evolution of the Ganjiang River Delta and Xihe Delta in recent 15 years.

POST-TRANSFORM SEDIMENTATION ON THE DEMERARA PLATEAU (SOUTH CENTRAL ATLANTIC): A CASE STUDY OF INITIATION AND EVOLUTION OF A CONTOURITE DEPOSITIONAL SYSTEM ON A MARGINAL PLATEAU

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The Demerara Plateau, part of the Surinam-French Guiana passive margin, is located at the western edge of the Equatorial Atlantic Ocean, close to the junction with the Central Atlantic Ocean. It consists of a prominent sub-horizontal marginal plateau (ca. 340 km long, 220 km wide) that extends the continental shelf down to ca. 4500 m water depth. The Demerara Plateau derives from the successive (1) opening of the Central Atlantic Ocean in a divergent mode during Jurassic times and (2) opening of the Equatorial Atlantic Ocean in a transform mode in the Late Cretaceous, and it was forming one of the last gateways before a complete connection of these oceans.

The Demerara Plateau has been intensively surveyed since these last years with four oceanographic cruises (i.e. GUYAPLAC (2003), IGUANES (2013), DRADEM and MARGATS (2016) cruises) that allow a better understanding of the structuration and evolution of this marginal plateau. Analysis and interpretation of seismic data (including 24 and 72-channel high-resolution seismic profiles) allow studying the architecture of post-transform deposits (i.e. post-Albian) and a better understanding of factors controlling the sedimentation along the Demerera Plateau.

Since the Late Cretaceous, the outer Demerara marginal Plateau is particularly prone to develop slope instabilities that evolve retrogressively from the transform border toward the inner Demerara plateau. The structure and steepness (up to ca. 15°) of the transform border plateau may play a key role in localizing these submarine landslides. Climate and thermohaline circulation are also thought to have a strong influence on the stratigraphic architecture and sedimentary evolution of this domain. Indeed, the Cretaceous/Tertiary boundary is expressed as an erosive surface on the Demerara Plateau while the Paleocene/Eocene Thermal Maximum corresponds to a sedimentary hiatus. A regional Middle to Late Miocene erosive surface records the onset of a major change in oceanic circulation that is related to the partial closure of the Isthmus of Panama and the development of ice caps (linked to the greenhouse/icehouse transition). Since then, bottomwater circulation seems to be the main factor influencing sedimentation on the plateau. Plio-Quaternary sedimentation is associated with the development of a contourite depositional system (CDS) linked to the activity of the North Atlantic Deep Water. This CDS is characterized by a longitudinal sediment distribution pattern including a series of moats and drifts that developed parallel to the transform border. Within the drifts, we evidence upslope-migrating sedimentary ridges. The main drift onlaps a Late Miocene/Early Pliocene mass-transport deposit on top of which giant comet tails develop. Finally, since the Late Miocene, the outer Demerara plateau shows a close interaction between contourite deposits and mass-transport deposits.

THE EARLY TOARCIAN OCEANIC ANOXIC EVENT: NORTHERN VS SOUTHERN HEMISPHERE PALEOENVIRONMENTAL RECORDS. INSIGHTS FROM SWITZERLAND AND CHILE

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Oceanic anoxic events (OAE) were periods of profound environmental perturbations throughout the Phanerozoic. As such, the Early Toarcian OAE (T-OAE, ~183 Ma) was both marked by oceanic anoxia and intense burial of organic matter, as well as by a major carbon-cycle perturbation evidenced by a negative carbon isotope excursion (CIE) possibly linked to the Karoo-Ferrar LIP. A variety of geochemical evidence indicates that a change towards global warming caused a general change in the hydrological cycle and triggered an increase in continental weathering rates, ultimately leading to the faunal and environmental change observed during the T-OAE. Hitherto, most studies were conducted in successions deposited in epicontinental seas in NW Europe, and interpretations from those relatively restricted basins were often extrapolated onto a global scale. With this, the diversity in T-OAE facies present in other basins, which is not always anoxic and/or enriched in organic matter, may not always sufficiently be taken into account in existing models.

In this study, we present new high-resolution sedimentological, geochemical and mineralogical datasets from successions deposited in different paleogeographic settings of the NW Tethys area (Jura, SubBriançonnais basin and Lombardian basin, Switzerland) and a section from the Andean basin (N Chile), in order to reconstruct, compare and confront the paleoenvironmental changes recorded in each hemisphere. The sections are correlated using their biostratigraphy, occurrence of the Early Toarcian negative carbonisotope excursion (CIE) and chemostratigraphy. The sedimentary expression of the T-OAE is contrasted between all studied sites confirming the role of local/regional conditions and mechanisms superimposed on the global environmental perturbation. The sections from the Jura and the Sub-Briançonnais have in common that they are characterized by the presence of organic-rich intervals formed in oxygen-deficient conditions, which were apparently more severe in the Jura. In contrast, the Lombardian basin records well oxygenated conditions. Likewise, the section from the Andean basin does not record a classical expression of the T-OAE; organic-matter burial was not favoured, while dynamic conditions are recorded in a marllimestone alternation. Based both on clay mineralogy as well as on chemical and weathering indexes, we observed that a humid and hot climate was recorded in the Swiss sites, whereas more arid conditions were prevailing in Chile. In all studied sites, fluctuations in total phosphorus content within the T-OAE intervals appear to have been mainly driven by changes in the detrital input rather than by anoxic conditions. Overall, our Swiss transect and its comparison with Chile indicates that the paleogeographic position of each studied section and the climatic conditions prevailing has ultimately modulated the intensity of the anoxic conditions.

APPLICATION OF DESCRIPTIVE AND MULTIVARIATE STATISTICAL ANALYSES FOR INTERPRETATION OF MULTIPLE DEPOSITIONAL PROCESSES OF EOCENE BASAL CONGLOMERATES IN THE BUDA HILLS, HUNGARY

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A coarse-grained clastic bed-set occurs at the base of the Upper Eocene marine succession in the Buda Hills, Transdanubian Range, Hungary. The conglomerate beds are directly underlain by Triassic formations. It is made up mostly of dolomite clasts, but the amount of volcanic clasts is also significant, locally. Due to the rather poor exposure conditions, the sedimentological structures of the basal beds are rarely visible. Therefore, the composition of the clastic material and the size and shape of clasts may serve as a base for the determination of the source area of the clasts and the interpretation of the transport and depositional processes.

We developed and applied the Rock Analyst IT application for exact measuring of the textural and petrographical parameters (size, quantitative composition, roundness, and sphericity) of about five hundred clasts. Then we applied a multivariate statistical grouping method, Combined Cluster and Discriminant Analysis (CCDA) to create homogeneous groups of sampling sites on the basis of various parameters (quantitative composition of conglomerates and shape of andesite and dolomite clasts). The result was a spatial pattern. According to our opinion, the sampling sites forming a homogeneous group on the basis of different criteria indicates deposition under similar geological circumstances and by similar geological processes.

Based on inferences of our analyses we can summarize the depositional conditions and depositional processes as follows. Intense karstic erosion took place from the end of the Cretaceous to the Priabonian which lead to an indented surface morphology. It was followed by a terrestrial deposition until the Late Eocene transgression. The sources of dolomite clasts were widely extended, but the volcanic clasts may have been derived from volcanic sources of rather limited surface exposure. During the Carnian volcanic dikes intruded into the Upper-Anisian – Ladinian platform dolomite in the area. A dike found in well Budaörs Bö-1 was the probable source rock of most of the andesite clasts in the Buda Hills. It is confirmed by the similar Carnian age (U/Pb age determination) and petrographic features of the dike and the andesite clasts.

During the long continental period, small fans were formed at the foot of slopes which supplied intermittent streams. Those fans, which were located close to the andesite source rocks contained in addition to high amount, relatively large and poorly rounded dolomite clasts, significant amount and poorly rounded andesite clasts, too. The andesite clasts may have been transported by intermittent streams along valleys. The transportation reduced the size and abundance of these clasts, andincreased their roundness and sphericity. The less rounded, high amount and big dolomite clasts which occur together with the andesite debris suggest that they were derived mostly from nearby small toe-of-slope fans. After the marine inundation of the area in the Late Eocene, a part of the previously accumulated terrestrial sediments reworked under marine conditions and mixed with redeposited abrasional dolomite pebbles bearing traces of boring organisms.

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THE CARBONATE HOLOCENE WEDGE OF NORTHERN LITTLE BAHAMA BANK: BETWEEN BANK AND DEEP DOMAIN

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Modern carbonate systems represent good analogs of ancient carbonate environments and allow connection between sediment facies and depositional processes. In modern carbonate environments, the tropical factory is mainly located on the shallow carbonate platform and platform margin. Particle export from Little Bahamas Bank margins (Bahamas) occurs mostly during episodes of winter cold fronts and hurricanes. On the northern LBB margin, the area connecting platform edge (20 mpwd) and area located at 300 mpwd is called the "uppermost slope". It is followed downslope by an area which exhibit hardly-consolidated sediment that opens to the small canyon heads at ~400 mpwd. The shallowest part of the uppermost slope is characterized by a succession of terraces and escarpments. Deeper than the steeper escarpment (marginal escarpment), i.e. at water depth varying between 170190 mpwd and 360 mpwd, the seafloor is dominated by a homogeneous, fine-grained, soft sediment wedge with thickness varying between 0 and 35 m and called the Holocene prograding wedge. It lies on a Pleistocene substratum and fills depression corresponding to lowstand erosional surfaces. On the deeper uppermost slope area, this wedge represents the main depocenter of fine-grained bank-derived sediment since the last bank flooding. Sediment deposited on the wedge globally correspond to periplatform ooze. Grain size analyses show that sediments are poorly sorted upslope and moderate sorted downslope.

CARAMBAR 1.5 cruise (2014) allowed to collect more than 150 km^2 of bathymetry data and 1120 km of high-resolution seismic profiles on the uppermost slope. Study area extends over 78 km from east to west and 3 km from north to south. Thirteen gravity cores sample this wedge. This new data set allows to describe both morphology and nature of sediments deposited along the uppermost slope. The aim of this study is to characterize the downslope and alongslope variation in Holocene wedge sediments and provide an accurate time framework for wedge deposition.

According to seismic profiles, 5 cores have sampled the entire wedge (2 on the eastern area and 3 on the western). However, XRF analyses showed that only cores collected in the western part of the study area recorded the last bank flooding, illustrated by progressive increase of Sr/Ca ratio with time. This increase is related to a progressive reactivation of bank productivity.

Radiocarbon datings obtained on 12 cores allowed to reconstruct sedimentation rates along and across the wedge. Extrapolation of these rates from cores base to wedge base using very high resolution seismic profiles shows that deposition happened initially in the western area (~ 8 ka cal BP) and shows a progradational trend. Beginning of deposition in the eastern area began later (~ 5 ka cal BP), and shows a retrogradational trend. Combination of XRF data and radiocarbon datings shows that the Holocene wedge formation is diachronous.

In future studies, high sedimentation rates might allow to characterize changes in wedge growing rate, and relate sediment accumulation to potential forcing by atmospheric processes.

DOWN TO THE DEEP: FROM CARBONATE PLATFORM TO ABYSSAL PLAIN

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Cruises CARAMBAR1 (2010), CARAMBAR 1.5 (2014), and CARAMBAR 2 (2016-2017) allowed to collect data in carbonate slope environments (Northern slope of the Little Bahama Bank-LBB): from the uppermost slope (20 mpwd to 300 mpwd, 13 cores), the upper (300 to 650 mpwd), middle (650 to 1000 mpwd) and the lower (1000 to 1300 mpwd) slopes (16 cores) and the slope down to the North Atlantic Abyssal Plain (1300 to 5000 mpwd, 14 cores). Available multibeam bathymetric data in the study area cover 23,800 km^2.

Using sedimentary core analysis and correlations, we propose for the first time an integrated study of the sedimentary processes that allow sediment export, transport and deposition on a complete carbonate system from the shallow platform (20 mpwd) to the ultra-deep Blake Bahama Basin (5800 mpwd) and across the 2000-m-high Blake-Bahama Escarpment (BBE).

Results show that the uppermost slope has been the most proximal sediment accumulation area of bank-derived sediment since the beginning of the Holocene flooding. At present-day, sediment transfer occurs seasonally after the arrival of winter cold fronts and during hurricanes. In this area, the Holocene wedge (96 mpwd to 300 mpwd) has recorded the periods of reactivation of bank productivity from 8 ka cal BP in the western part to 5 ka cal BP in the eastern part.

At deeper water depths, small valleys connect the uppermost slope to canyon heads located on the upper slope 400 mpwd. Small canyons are about 15 km long and extend down to water depth of ~1000 mpwd. Cores collected parallel to canyons axis show a significant amount of periplatform ooze. Sedimentation rates along the middle slope vary mostly according to the flooding or the emersion of the platform and the induced switching on/off of the carbonate factory. Highstands correspond to active bank productivity and high export rates of fine-grained sediments (about 10 cm/ka) from platform to uppermost slope, while lowstands correspond to emerged bank with low biogenic carbonate production and low sedimentation rates (few mm/kyr) and coarse-grained particle deposition. Downslope of canyons, on the lower slope, distributary furrows (~10 km-long, extend from ~1000 to 1100 mpwd) lead to large depositional areas (from ~1100 to 1300 mpwd) on the southern termination of the Blake Plateau.

The Blake Plateau is incised by the Great Abaco Canyon, which runs along 140 km parallel to the LBB, from 1300 to 4800 mpwd. Canyon morphology shows a giant incision that links the lower slope to a deep tongue of deposits at the base of the BBE. Canyon flanks are dissymmetric. Seismic profiles show that southern plateau seems eroded with a thinner contourite cover (~375 m) than the northern plateau (~450 m). These deposits contain episodic green clay layers that represent good stratigraphic markers between the Blake Plateau and the lower slope of LBB.

LIPID BIOMARKER DATA REVEAL PALEO-DYNAMICS OF METHANE FLUX IN RECENT CWC CARBONATE MOUND SEDIMENTS

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Fluctuations of the sulphate-methane transition zone (SMTZ) are reported in sediments from Alpha Mound, a modern cold water coral (CWC) carbonate mound in the Gulf of Cadiz. Alpha Mound is a 30-meter-high carbonate mound situated on top of an escarpment in the El Arraiche mud volcano field. Previous work has shown that Alpha Mound is subject to hydrocarbon-bearing fluids, which have left a strong imprint on the mineralogy and geochemical profiles. However, only molecular techniques and pore water geochemistry have been able to elucidate the current presence of AOM in response to methane seepage. Subsequent paralleled geochemical profiling of pore waters and sediments could not pinpoint fluctuations of the SMTZ and thereby gain a better understanding of its temporal and spatial distribution. In this study, the analyses of lipid biomarkers and their compound-specific carbon isotopes, together with sedimentary petrography and mineralogical XRD analyses were applied to (1) assess the past and present occurrence of AOM and to (2) distinguish methane-derived diagenesis from other early diagenetic processes. By applying lipid biomarkers, past and present occurrences of AOM reveal fluctuations of the depth of the SMTZ in the past few hundred thousand years. Fluctuations of the SMTZ resulted in semi-lithification of the mound at particular depth horizons by high Mg-calcite cement precipitates. In contrast, authigenic dolomite is more abundant in this profile and likely is the result of organoclastic sulphate reduction. The presence of aragonite needles points towards oceanographic processes at a well-identified erosional surface. Results of this study demonstrate that lipid biomarker analyses can be successfully applied to understand the paleo-dynamics of a SMTZ. Combined with petrographic and mineralogical analyses, processes and mechanisms responsible for SMTZ fluctuations are discussed. Semi-lithification events in the CWC carbonate mound sediment proof to be sensitive recorders of methane seepage through space and time.

SEDIMENTOLOGICAL VARIABILITY WITHIN THE UPPER ORDOVICIAN AND SILURIAN (LLANDOVERY-WENLOCK) FORMATIONS. PROSPECTIVE FOR SHALE GAS IN NORTHERN AND EASTERN POLAND (EXAMPLES FROM SELECTED BOREHOLES)

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Thick sequences of Upper Ordovician and Silurian fine-grained deposits occur in N, NE and E parts of Poland, in the East European Platform area. For a few years now, they have been of interest because of their unconventional hydrocarbon potential. The present study aims to identify prospective zones and to determine the prospects for occurrence of unconventional gas resources within them. One of the methods used is sedimentological analysis.

The present study provides these dimentological characteristics of Ordovician (Sandbian-Hirnantian = Caradoc-Ashgill) and Silurian (Llandovery-Wenlock, lower Ludlow) deposits in the north-eastern (Baltic Basin) and south-eastern (Podlasie-Lublin Basin) parts of the East European Platform. In both the basins, the formations prospective for shale gas were analysed: Sasino Fm., Paslęk Fm. (including Jantar Mb.), Pelplin Fm., Udala Fm., Wrotnów Fm. and Terespol Fm. The purpose of the work was to determine lithofacies within shale deposits, their sedimentary characteristics, and the spatial pattern of the facies diversity within these formations. Drill cores from 16 deep wells were thoroughly examined.

The facies analysis covered lithological-sedimentological logging in centimetre scale, and included determination of lithology, grain size, presence and type of sedimentary structures (lamination, bedding, erosional boundaries), presence, size and type of concretions (pyrite, carbonate, phosphorite), degree of bioturbation, sediment colour, calcium carbonate content, type and amount of macrofossils.

Based on lithological and sedimentological criteria, 34 lithofacies and 11 lithofacies associations have been distinguished. It was found that the most promising lithofacies are L-1 (massive claystones / clayey mudstones, without bioturbation), L-3 (claystones / clayey mudstones with single laminae and lenses) and L-4 (laminated claystones and/or clayey mudstones without bioturbation) associations. They are characterised by dark grey colour, a very low degree or lack of bioturbation, and rare sedimentary structures, and they often contain small pyrite concretions. They dominate in the Sasino Fm., Paslęk Fm. (but only in the Jantar Mb.) and Pelplin Fm. To a much lesser extent, they are present in the Udala Fm., Terespol Fm. and Paslęk Fm. (excluding the Jantar Mb.).

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ALTERNATIVE GEOSTATISTICAL APPROACHES TO MODEL ALLUVIAL DEPOSITS USING LARGE SUBSOIL DATA REPOSITORIES: THE PORTO MARGHERA CASE STUDY (VENICE, NE ITALY)

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Progress towards improved modelling of porous groundwater reservoirs requires the use of large datasets of sedimentological and hydrogeological information from boreholes. Careful integration and analysis of these data can indeed allow for robust conceptual models, which are imperative for appropriately choose the geostatistical method to be used when simulating and/or interpolating reservoir properties in 3D.

The Porto Marghera case study (inland of Venice, NE Italy) covers an area of 4 x 11 km, hosting diverse industrial activities over most of the last century, which resulted in heavy pollution of the subsoil and the nearby lagoon of Venice. The subsoil of the site consists of loose sediments of late Pleistocene-Holocene age which can be grouped into three main stratigraphic units: i) the Late Glacial Maximum (LGM) sandy fan delta of the Brenta river (BFD hereafter), ii) the post-LGM lagoonal deposits and iii) the preset-day anthropogenic backfill. A well-developed and laterally continuous paleosoil provides a key horizon separating BFD from younger deposits.

Numerous boreholes with continuous coring were drilled during the site remediation works undertaken in the late 90's, mostly for assessing and monitoring pollutants concentration in the shallow subsurface (up to 30 m). The stratigraphies of more than 1400 boreholes, coded by grain size-based soil classification standards, were later on collated into a database, thereby providing a comprehensive dataset of the subsoil heterogeneity. In this work we deal with the modeling of BFD only, which can be ideally subdivided into three main depositional elements, namely 1) channels with sandy infill; 2) levees dominated by sandy-silty mud and 3) a dominantly clayey floodplain with rare peats. Sediments were grouped into three operative indicator facies based on dominant grain size (i.e. sands, sandy-silty mud and clayey mud) with peats as an accessory facies.

Facies distribution was simulated using both pixel-based (e.g. Sequential Indicator Simulation SISIM, Multiple Point Simulation MPS, Truncated Gaussian simulation TGS) and object-based methods routinely employed in modelling of groundwater and oil reservoirs. The modelling output includes voxelby-voxel (cell size: 25.0 X 25.0 X 0.2 m) sets of equiprobable hydrofacies distributions, allowing for a probabilistic approach to reservoir body characterization.

To test the sensitivity of geostatistical modeling on boreholes placement, facies were modeled in separate sessions using increasing fractions (i.e. 20%, 40% and 80%; training dataset, hereafter) of the total number of boreholes available. The boreholes not used in the modeling (validation dataset, hereafter) were later on used for cross-validation purposes. Analysis of spatial anisotropy, variography and compilation of vertical proportion curves were carried out in each modeling session without previous knowledge of the full dataset, prior to run 25 conditional simulations.

The comparison of results across different modelling runs and approaches are discussed with reference to connectivity of the main sandbodies and validated by means of flow simulation on a well-constrained test volume. This analysis indicates that facies models obtained using alternative hydrofacies modelling approaches translate into remarkably different connectivity scenarios.

PALEO-ENVIRONMENT EVOLUTION THROUGH CLIMATE CHANGE: A HOLISTIC PERSPECTIVE

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The complex interactions between organisms and their environments are an important aspect of the planet's evolution. Biotic and abiotic systems evolve with time and leave traces in the biosedimentary record. To infer the evolution of the ecosystems based on solid paleoenvironmental reconstructions three ingredients are needed: a well-established sedimentological and stratigraphic framework, a good taxonomy and a comprehensive ecological background.

The lower Pleistocene marine succession of the Arda River, cropping out in Northern Italy, represents an excellent site where to apply this kind of multidisciplinary investigation to resolve past ecosystems dynamics. The well preserved sedimentary structures and the excellent preservation of body and trace fossils make of this marine succession a case study where to compare the abiotic and biotic components within a key-time interval of climate change. The early Pleistocene was, in fact, characterized by climatic oscillations related to glacial/interglacial cycles, with the Mediterranean area being affected by these changes both in marine and continental settings.

The studied succession represents a subaqueous extension of a fluvial system, originated in a tectonically active setting during phases of advance of fan deltas affected by high-density flows triggered by river floods. It documents a fully marine and well oxygenated environment, bounded at the top by continental conglomerates indicating a sea level fall and the establishment of a continental environment. Indeed, a general regressive trend is observed through the section, passing from a prodelta to a delta front and intertidal zone settings; lower order transgressive and regressive cycles with shifts from lower foreshore-shoreface to offshore transition environments have been identified, with water depths ranging between 5 and 50 m. The hydrodynamic energy and the sedimentation rate are not constant through the section, but they are influenced by hyperpycnal flows; the latter caused an increase in terrigenous input linked to fluvial floods, whose sediments are mainly supplied by an increase in the Apennine uplift and erosion, especially after 1.80 Ma. This research allowed us to evaluate to which extent sedimentology, body fossil paleontology and ichnology complement one another and derive general implications for their combined use. This integrated approach, in some cases, has led to possible misinterpretations and disagreements between the different tools used, but generally, these three different approaches complement quite well one another, giving strength and robustness to the obtained results.

TIDAL FACIES, GEOBODIES HETEROGENEITIES AND GEOMETRIES IN THE GIRONDE ESTUARY (SW FRANCE)

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The Gironde is a macrotidal tide-dominated estuary, located at the confluence of the Dordogne and Garonne estuarine channels in the Aquitaine basin (SW France). Gironde is a very muddy estuary, consequently the facies, geobodies heterogeneities and geometries presented here are specific of this type of environment of deposition.

The estuarine tidal channels (Garonne and Dordogne) extend along a 55 km long meandering channel section, from the bay-line (located 130 km seaward of the estuary mouth) to the Gironde estuary funnel. Typical estuarine heterolithic point bars are deposited in the meanders. At the surface of these point bars, tidal facies show slack-water clay drapes, clay-drapes couplets, bidirectional dune foresets, centimetres-thick fluid mud layers and abundant mud clasts of variable sizes. Neap-Spring cycle deposits can also be observed. The vertical facies association observed on piston cores shows both a fining upward grain-size trend (from gravels to medium-grained sands) and a thinning upward trend of the sand beds (from dunes to ripples). Those heterolithic point bars are highly-segmented round-shaped reservoir geobodies (internal seals are fluid mud layers and amalgamated clay-drapes), which average dimensions are 1 km of diameter and 8 m of thickness.

The Gironde estuary funnel is 75 km long, it extends seaward of the junction of the 2 estuarine channels, up to the estuary mouth. In its landward part, the funnel is about 5 km wide, it is occupied by a 30 km long bay-head tidal delta composed of muddy tidal channels and sandy tidal bars. The tidal facies observed on the tidal bars are very similar to the facies described on the heterolithic point bars. The vertical facies association observed on piston cores shows both a gentle coarsening upward grain-size trend (from fine-to medium-grained sands) and a thickening upward trend of the sand beds (from ripples to dunes). Those sandy tidal bars are long and narrow reservoir geobodies, which average dimensions are 4 km long, 600 m wide and 5 to 10 m thick. The internal architecture of the tidal bars has been reconstructed thanks to very high resolution seismic, those sandy tidal bars are segmented by extensive meter-thick mud layers dipping laterally or longitudinally vs. the long axis of the bars.

At the Gironde estuary mouth, a 30 m deep tidal inlet channel is present. It is filled by coarse-grained sands with marine shells eroded off the coast and introduced within the tidal inlet by the flood currents. The same tidal inlet channel-fill deposits are also observed thanks to very high resolution seismic lines shot on the shelf 10 km seaward off the estuary mouth; they exhibit large-scale lateral accretion surfaces generated during the lateral migration of the tidal inlet channel. The tidal inlet channel-fill geobody is 40 km long, 4 to 5 km wide and 20 to 30 m thick. It is the largest and thickest reservoir geobody deposited within the Gironde estuary.

ROLE OF EVAPOCONCENTRATION IN SEDIMENT-HOSTED EXOTIC-CU MINERALIZATION, ATACAMA DESERT, CHILE

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Exotic-Cu deposits are mineralized bodies composed of copper oxides, silicates, chlorides and carbonates and their formation responds to the lateral transport of acidic Cu-bearing aqueous solutions sourced from porphyry copper systems. In the Atacama Desert, exotic-Cu mineralization occurs within poorly consolidated Late Cenozoic cover gravels and even in the porosity of the underlying bedrock. Although this type of mineralization is controlled by numerous factors, the importance of the hydrological and palaeoenvironmental setting is not well defined.

Here we provide new $\delta^{13}C$ and $\delta^{18}O$ data and hydrochemical simulations from the El Tesoro Central exotic-Cu deposit (22°57'S, 69°5'W) in northern Chile. This deposit consists of two ore bodies hosted by Late Cenozoic gravels deposited in an arid continental environment which was dominated by alluvial fans with sub-surficial ponded water bodies formed at the foot of the fans or within the interfan areas. Both exotic-Cu bodies are mainly composed of chrysocolla (Cu-silicate), copper wad (Cu, Fe-bearing manganese oxyhydrates) and atacamite/paratacamite (Cu-chlorides). Quartz, opal, calcite and gypsum are present as well.

Thirty-five $\delta^{13}C$ and $\delta^{18}O$ analyses were performed on carbonate-bearing fine-grained matrix from samples distributed along the entire sedimentary sequence exposed in El Tesoro Central copper mine and also on specific points of exotic-Cu hand samples. The obtained $\delta^{13}C$ and $\delta^{18}O$ values vary from -5.97‰ to -1.98‰ (VPDB) and -11.39‰ to -2.37‰ (VPDB), respectively. The most remarkable features are (1) the excursions to heavier values (approximately 2‰ or 3‰) of both the $\delta^{13}C$ and $\delta^{18}O$ values within both exotic-Cu bodies and (2) the relatively good covariance of the $\delta^{13}C$ and $\delta^{18}O$ values from both exotic-Cu bodies. These observations, together with previous facies analyses and petrological descriptions, indicate that the exotic-Cu mineralization could by triggered by the evapoconcentration of near-surface ponded Cu-bearing aqueous solutions during a very early diagenetic stage.

In order to test the role of the evapoconcentration in the exotic-Cu mineralization, we performed simple hydrogeochemical simulations using the PHREEQC software. A spring water analysis from the Andean Precordillera with a representative chemical composition was selected and carried to equilibrium with common Cu-and Fe-bearing sulphides from a porphyry copper system and with atmospheric CO_2. The resulting water sample was 99.9% evaporated and the obtained mineralogy (chrysocolla, atacamite, quartz, opal and chalcedony) was very similar to that one observed in El Tesoro Central.

We conclude that the evapoconcentration of near-surface ponded Cu-bearing aqueous solutions is a viable ore-forming mechanism in the El Tesoro Central exotic-Cu deposit. This complements the traditional genetic model based on the gradual neutralization of highly oversaturated Cu-bearing solutions that progressively cement the gravels and underlying bedrock regardless of the depositional environment.

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NEW FORAMINIFERAL PROXIES FOR WESTERN TETHYS LATE OLIGOCENE (CHATTIAN) BIOSTRATIGRAPHY AND PALEOBIOGEOGRAPHY

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The study of Oligocene carbonate platforms from the Prebetic Domain (SE Spain) allowed us to refine the foraminiferal biostratigraphy. It has also revealed the presence of characteristic species or genera, easy to identify, which facilitate the biostratigraphic interpretation. Some of the recognized species provide significant clues to better understand the paleobiogeography and migration routes of foraminiferal genera during the Oligocene and Miocene, and thus a better comprehension of the paleoceanographic conditions during this time interval.

Risananeiza. This genus is frequent in late Oligocene rocks from the western Tethys, from eastern Spain to Turkey. It is easy to identify from its almost planispiral coiling test, with large pillars and canal funnels on both ventral and dorsal sides. The two known species, *R. pustulosa* and *R. crassaparies* have an identical stratigraphic range, limited to Shallow Benthic Zone 23, and thus they are useful markers for the late Chattian.

Amphistegina mammilla. Characterized by a nearly planispiral test with umbonal bosses on both sides and lenticular to rhomboidal outline, it is easily distinguished from the common Oligocene species, *A. bohdanowiczi*. Previously thought to have been originated in the Indo-Pacific region, entering the Parathethys in the Middle Miocene, the presence of *A. mammilla* in Chattian rocks of western Tethys changes this interpretation and reverses the migration route.

Sorites sp.: Previously thought to have been originated during the Middle Miocene, *Sorites* occurs in Rupelian and Chattian rocks of the western Tethys (Spain, France and Italy). It is absent in Turkey, but it seems to be present also in Rupelian rocks from Iran. This patchy distribution points to apolyphyletic origin, and agrees with DNA studies of the recent species. Our new data places the (first) origin of *Sorites* in the Oligocene of the western Tethys, instead of the Miocene of the Indo-Pacific region as currently postulated. Tethyan Oligocene *Sorites* are structurally different from Oligocene-Miocene soritids of the Caribbean region, ruling out immigration from this bioprovince as occurred with miogypsinids and lepidocyclinids. Considering also *A. mammilla*, and possibly *Risananeiza*, the western Tethys was a region of origination of new foraminiferal species and genera during the Oligocene.

Nummulites. Data from the Prebetic domain confirm that *Nummulites* occurs throughout all the Oligocene, with *N. vascus* and *N. kecskemetii* in the Chattian of the western-central Tethys. *Victoriella conoidea* occurs in Oligocene and Miocene rocks. Larger specimens, > 2.5 mm, are only found in rocks of late Chattian age. *Cycloclypeus mediterraneus* was considered to go extinct and replaced by *C. eidae* at the SBZ 22B-23 boundary. Its occurrence in the late Chattian of the Eastern Betics indicates an asynchronous extinction in the Tethys.

FROM SUBMARINE SCREE FANS TO TURBIDITES: CASE STUDIES ON CONGLOMERATE/CALCARENITE SYSTEMS IN S-E FRANCE

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Carbonate submarine gravity systems largely outcrop in the French subalpine chains from the Tithonian to the Eocene. Tithonian breccias of the Vocontian Trough build different kinds of lobes going from pure draping systems to avulsion dominated. In some of them, the head of individual breccia beds show progradation features passing downward to massive ungraded breccia. The same is encountered in a mixed conglomerate-calcarenite slope apron of Coniacian age. Individual beds show a prograding spreading forward internal geometry beginning with conglomerate and finishing with a calcarenite cap bearing the same internal geometry. The end member of such short, highly sloped systems are scree fans resembling in shape and internal features their subaerial counterparts. There is a clear boundary between fans fed by grainy avalanching bearing a very regular, high-angle stratification, and fans fed by en-masse avalanching. The occurrence of a strong hydraulic jump at base of the slope probably explains the occurrence of the prograding plugs (either conglomeratic, or calcarenitic, or both) in the head of individual beds found in some cases.

GROW FAULTS AFFECTING GEOMETRY AND SEQUENCE STRATIGRAPHIC RECORD ON A CARBONATE PLATFORM EDGE: SOUTH VERCORS URGONIAN PLATFORM, FRANCE

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The south Vercors Urgonian carbonate platform, of Barremian to lower Aptian age, is rimmed by thick calcarenite units around the Glandasse Plateau, Archiane Cirque, and Montagnette summit. The internal geometry of the Bi5 lithostratigraphic unit of Arnaud (1981), of late early Barremian age, has been studied along three N-S oriented cliffes. The change in the internal geometry is interpreted as the result of synsedimentary grow faults. Sequence stratigraphic interpretation of the unit therefore change from one place to another due to the disruption of the regular accommodation rate pattern that would be expected on a steadily subsiding margin.

SHELL ACCUMULATION PROCESSES IN A COASTAL WAVE-DOMINATED ENVIRONMENT: A PHYSICAL MODELLING APPROACH FOR A LAKE MARGIN SCENARIO

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Coquinas are important carbonate oil reservoirs on Pre-salt sequency of brazilian marginal basins, generated from shell accumulations on rift-lake margin environments, whose the waves and the coastal currents were the main hydrodynamic agent of transporting and reworking. In order to investigate the sedimentological processes of shell accumulation by wave motion, physical modelling of coastal environment have been performing in laboratory. The experimental setup is composed by a channel (40 m long, 1 m wide, 1.1 to 0.56 m deep), a wave generator, fine sand (quartz) and shells of bivalves and gastropods, whole and fragmented, with size beetwen 4 and 20 mm. The experimental scenario reproduces a rift-lake margin, based on the coastal region of Kigoma, in the east margin of the Lake Tanganyika (Africa). That place was used to setup the model boundary conditions (in a 1/20 scale) as: the coastal gradient and the wave conditions. Thus, fair weather and storm wave conditions were alternately simulated, together with a increasing input of shells during the experiments. The shells were put on the sandy bed below the fair weather wave base. Two main types of shell accumulations were generated: (I) shells with interstitial sand and (II) clean shell deposit. Type I accumulation were generated at the first storm wave breaking point, such a bar shaped deposit, and also at the more distal point of the coastal profile, in the wave shoaling zone, as a sand and shells sheet. Type II accumulation were generated between the Type I deposits, before of the storm wave breaking point where the wave shoaling process was fairly increased, generating a flat deposit of whole shells and fragments over the channel bottom. Also, incipient shell accumulation was generated along the entire coastal profile, highlighting the accumulation of sparse gastropods shells at the backshore/swash zone. Those shells were transported by rolling and saltation from the fair weather wave base to the swash zone of storm wave condition. It was observed three sedimentary processes of shell accumulations dynamics: winnowing, reworking and dynamic bypassing. Winnowing process (removing of intertitial sediment) have occurred during storm conditions at the shoaling zone, resulting in the Type II accumulation. Reworking process (motion of shells and sand) have happened during storm and fair weather wave conditions, at the zones of breaking and swash, resulting in the Type I accumulation. Dynamic bypassing process (sandy ripples migration) was observed during the fair weather wave conditions, at the wave shoaling zone, mainly at the top of storm bar, resulting inalternated burial and exhumation of the shells. Partial qualitative analysis indicate that the shells long axis tends to orientate perpendicular to shoreline at the wave swash zone, randomly at the wave breaking zone and parallel at the wave shoaling zone. The characterization of the dynamic processes and their depositional products, observed in the experiments, provide a set of diagnostic characteristics which can improve the interpretations about depositional models of coquinas facies on rift-lake margin environment. Another results and more detailed discussions are being currently realized.

SEQUENCE STRATIGRAPHY OF THE CENOZOIC SUCCESSION IN THE VICTORIA LAND BASIN, ANTARCTICA: A LONG-TERM ARCHIVE OF PALAEOENVIRONMENTAL CHANGE

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The Victoria Land Basin (VLB) forms part of the failed West Antarctic Rift, and preserves a Cenozoic succession up to 4 km thick that records the onset of Cenozoic glaciation, and the history of Antarctic glaciation over the past 34 m.y. This succession is relevant both to investigations of modern climate change, and to studies of long-term (palaeo)environmental change in general. This presentation provides a sedimentological and stratigraphic review of the VLB succession, based on analysis of several continuous drillcores acquired over the past 40+ years, and supported by seismic stratigraphic analysis of a large array of seismic reflection data. An array of fifteen lithofacies is recognized within the VLB Cenozoic succession, ranging from fossiliferous and diversely bioturbated mudrocks and diatomites, texturally mature sandstones and conglomerates, through mixed mud-and sandstones with dispersed gravel with restricted bioturbation, to diamictites and associated lithologies. These facies record a variety of marine, glaciomarine, proglacial and at times (sub) glacial environments. Locally, volcanic and volcaniclastic deposits are interbedded in the succession. Lithofacies are arranged in repetitive vertical stacking patterns (depositional sequences) that record glacial advance-retreat cycles with attendant relative sea-level changes. Seven varieties of depositional sequences (stratigraphic motifs) are recognized within the succession as a whole, and interpreted to record a spectrum from cold, polar glaciated environments such as that of today (Motifs 1-2), through varying degrees of glacial influence with abundant meltwater contributions (Motifs 3-6), to settings unaffected by glacial ice (Motif 7). Overall, there is a gradual trend upward through the succession from Motif 7 at the base towards Motif 1 at the top, but the trend is not monotonic. A significant conclusion of this work is that a record of dynamic climate and glacial conditions is preserved through the entire 34 m.y. period of the Cenozoic icehouse, at least in the VLB. Intervals characterized by consistent stratigraphic style (motifs) are recognised throughout the VLB succession. These intervals are of 1-6 m.y. duration, each containing numerous depositional sequences. They are 1-2 orders of magnitude longer than glacial-interglacial cycles, and record periods of relatively consistent climatic and paleoenvironmental variations They are considered to reflect convolutions of orbital parameters that remained stable for periods of 106 a, and then switched to alternative configurations. Such intervals are directly analogous to 1-8 m.y. intervals characterized by glaciogenic strata that are preserved within the Late Palaeozoic of eastern Australia among other areas, and may be a recurring stratigraphic response to icehouse climate regimes through geological time.

FALLING-STAGE STRATAL ARCHITECTURE ILLUSTRATED IN A DEPOSITIONAL DIP TRANSECT THROUGH THE FLUVIO-DELTAIC FERRON SANDSTONE (CRETACEOUS) OF SOUTHERN UTAH, USA

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Depositional-dip-oriented transects through coastal plain to nearshore marine domains are essential elements of generic sequence stratigraphic models for continental-margin successions. Many questions remain about the validity of these models, however, because well-constrained outcrop examples are sparse. Presented herein is the first detailed study of a 30-km long, almost continuously exposed, depositional dip transect through nonmarine and marine facies of the fluvio-deltaic Ferron Sandstone in the southern Henry Mountains Syncline of southern Utah, USA. This transect is connected to the southern end of a previously documented, 67 km long, depositional strike-oriented section. Excellent exposure reveals relationships among facies, stacking patterns, and bounding surfaces across three orders of sequences and various shoreline trajectories. Fundamental sequences are dominated by falling stage systems tracts, suggesting a regime dominated by long, gradual relative falls in sea level punctuated by shorter rises. This pattern is attributed to subsurface growth of a fold (50 m amplitude, ~ 100 km wavelength) during accumulation of the Ferron Sandstone. Widespread fluvial downcutting is generally absent. Distributary channel sandstones pass down dip into broadly contemporaneous shoreface and delta front sandstones. A major sequence boundary divides the study interval into two composite sequence sets. Within the Lower Composite Sequence Set, Sequence Sets IIII comprise eastward-dipping, offlapping clinothems defining a descending, regressive shoreline trajectory (falling stage deltas). Within the Upper Composite Sequence Set, Sequence Sets IV – VI overlie a thin transgressive deposit and consist of progradational to aggradational clinothems (highstand deltas). Key bounding surfaces are similar at all scales of the hierarchy: they are diachronous, cryptic, and pass down depositional dip into conformable surfaces where they are almost impossible to recognize as key surfaces. Differentiation between units and surfaces that develop at different hierarchical levels is possible only by integrating detailed outcrop observations with regional stratigraphic architecture.

AN INTEGRATED PALAEOENVIRONMENTAL ANALYSIS OF THE PERMO-TRIASSIC BOUNDARY SUCCESSION IN EASTERN AUSTRALIA

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This paper provides initial results from ongoing research aimed at elucidating the timing, duration, and causes of the end-Permian mass extinction (EPME) in eastern Australia. This succession was accumulated in a continental margin setting, which contrasts with most previous studies of the EPME that were located in deep marine or continental interior settings. Our study also differs from earlier work in that it represents an extensive, high to mid-palaeolatitude transect (70-40 degrees south). The succession is constrained by a large body of new, precise, absolute ages (CA-IDTIMS method) that allow resolution of timeframes at unprecedented levels of detail. These factors allow a number of questions to be addressed: 1. Did the EPME occur precisely at the Permo-Triassic boundary at 251.9 Ma?, 2. Was the terrestrial extinction in eastern Australia synchronous with the marine extinction based on palynological and geochronological correlations with Western Australian and Chinese successions?, 3. Were major environmental changes synchronous with the EPME and with the Permo-Triassic boundary?, 4. What environmental factors were the probable drivers of the EPME in eastern Australia, and 5. Which biophysical-climate feedbacks led to amplification of the environmental stresses? The eastern Australian succession is stratigraphically complete, and preserves the entire Permian system in addition to the Lower and Middle Triassic. Previous work by us has established that icehouse conditions of the late Palaeozoic Ice Age persisted longer in eastern Australia than in other regions of Gondwana. Indeed, the new geochronological data indicate that the ice age extended into the Late Permian, after the initial faunal extinction at the Guadalupian-Lopingian boundary, and only ~ 2 m.y. before the EPME at 251.9 Ma. This suggests that the EPME may represent a final biological tipping point at the end of a protracted interval of increasingly severe paleoenvironmental conditions associated with the transition from late Palaeozoic icehouse to Mesozoic hothouse conditions. Initial results suggest that the main biotic turnover was not synchronous with the Permo-Triassic boundary, and that major changes in palaeoenvironmental conditions did not occur until somewhat later. Among the evidence for this initial finding is that there is no immediate change in architectural style among coastal fluvial sediment bodies at the boundary, and the Permian Glossopteris flora persists well into the Triassic succession at field sites in New South Wales. This suggests that the EPME occurred somewhat later in high palaeolatitudes than elsewhere.

THE EVOLUTION OF THE RIVER NILE FROM OLIGOCENE TO RECENT TIMES, AS DOCUMENTED IN THE SEDIMENTARY RECORD OF THE OFFSHORE NILE DELTA

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We present the first detailed multiproxy provenance study of Oligocene-Recent Nile delta cone sediments, and show that the palaeodrainage of the River Nile and composition of the sediments supplied to the delta cone have remained relatively stable over the last 30 Ma. Our study of detrital zircons and Sm-Nd bulk composition of Oligocene-Recent Nile delta cone sediments shows that the Ethiopian Large Igneous Province has been contributing detritus to the Nile since the uplift of the Ethiopian Highlands at c. 31 Ma. The detrital zircon signature of Nile delta cone sands is dominated by grains derived ultimately from the Arabian Nubian Shield and post-collisional granites related to the Pan-African Orogeny. A subordinate population of grains derived from pre-Neoproterozoic cratonic basement is also present. The signature of the cone sands is identical to that seen in recycled Phanerozoic sedimentary cover sequences which overlie the Arabian-Nubian Shield and cratonic base-ment rocks, and it is these sedimentary rocks that are thought to be the source of most zircons found in the Nile sediments. Pre-Neoproterozoic zircons are more common in Oligocene and Pliocene cone sands than in the Miocene and Pliocene. This is interpreted as increased input from locally eroded sediments from the Red Sea Hills at these times, due to uplift of the Red Sea Hills in the Oligocene, and infilling of the Nile canyon by Red Sea Hills detritus in the Pliocene following down-cutting during the Messinian Salinity Crisis. The relative continuity of the provenance signal of the Nile sediments across 30 Ma of changing climate shows that aeolian dust, which is commonly invoked as an end-member in modern river studies of the Nile, is unlikely to be an important source to the delta cone samples studied here. In Nile cone sands, the proportion of stable heavy minerals increases markedly down section, indicating extensive diagenetic dissolution of less stable minerals. Tracer isotopes in the Nile cone muds do not show a systematic variation with depth and time, but instead are controlled by provenance and mineral sorting effects.

LATE QUATERNARY TO PRESENT SEDIMENTATION IN THE ZAMBEZI FAN (MOZAMBIQUE CHANNEL)

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Recent studies on turbidite systems at low-latitudes (e.g. Weber et al., 1997, Ducassou et al., 2009 and Picot et al., 2016) proved that sediment delivery to deep sea can persist during relative high sealevel periods. Yet, low-latitude turbiditic systems received little scientific attention. This study focuses on the Zambezi turbidite system (~2000 km long x 500 km wide), located within the Mozambique Channel which is characterized by high hydrodynamic conditions. Based on bathymetry, sub-bottom profile data and piston cores, this study aims to characterize the recent architectural evolutions of the Zambezi turbidite system and to interpret these in terms of climate, tectonic and hydrographic forcing. The Zambezi Valley has low sinuosity and a declining slope with increasing depth (from 4.2 to 0.8 %) affected by several knickpoints, indicating that the valley is not at an equilibrium state. This valley is wide (32 km) and is characterized by a distinct narrower, U-shaped, deep thalweg. This thalweg shows a large variability in width (3 to 10.5 km) and has a general widening trend downstream. The Tsiribihina Valley, the main tributary of the Zambezi Valley coming from Madagascar, is narrower (15 km), more sinuous and appears slightly perched (17 m) above the Zambezi thalweg at the confluence. Bathymetric and sub-bottom profile interpretations, within the valley as well as on the flanks, indicate erosional and vacuity processes that currently dominates the whole Zambezi Valley. Fine-grained turbidite deposition is only recognized in a confined basin at the base of Mozambican continental slope and as few channel-levee systems at the outlet of the Zambezi valley. Sedimentological, geochemical and isotopic analyses were performed on multiple sediment cores recovered at several sites in the depositional area. In all sites, except the Tsiribihina Valley flank, turbidite events are infrequent and sedimentation rates are very low (average of 2.7 cm/ka). In the southern area a regional change in color is associated with a stop in turbiditic activity during midMIS6. Meanwhile an increase in turbidite activity from mid-MIS6 to present is found in the confined basin. These results indicate a shift of depocenter in the Zambezi system during MIS6 (~150 ka) from the distal part towards the confined basin more upstream. The origin of this shift remains unknown (recent modifications in the Zambezi catchment?).

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CARBON AND OXYGEN STABLE ISOTOPES FROM THE HOMO-BEARING FLUVIO-LACUSTRINE AALAT SECTION (PLEISTOCENE DANDIERO BASIN, ERITREA)

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Stable isotope studies from paleosoils developed in fluvio-lacustrine-palustrine environements can provide a proxy for paleoenvironmental change. This tool has the potential to elucidate if climate has any influence in the sedimentary facies.

We analysed three types of carbonate concretions from paleosoils developed along the 285-m thick Aalat section. The most abundant concretion type are nodules (mean diameter between 4-5 mm to 2-3 cm) with poorly defined boundaries that occur in sandy silts. The other common carbonate type is represented by nodules (mean diameter between 3 mm to 2 cm) with well-defined boundaries found in silty deposits. Finally, the third type only occurs in three sites. It consists on centimetric vertical tubular concretions. The XRD analysis revealed that most of carbonates are composed of calcite. However, some specimens also contain noticeable amounts of dolomite. We excluded these dolomite bearing samples from our isotopic study. The $\delta^{13}C$ isotopic composition of the calcite concretions is comprised between -6.94 and -0.56 ‰, and the $\delta^{18}O$ ranges from -11.18 to -3.66 ‰. In addition to carbonate concretions, we analysed laminated mudstones and wackestones. As occurs in the concretions, some limestone samples contain dolomite in addition to calcite. The $\delta^{13}C$ and the $\delta^{18}O$ values of the calcite-dominated limestones range from -4.65 to -2.78 ‰ and from -8.66 to -6.71 ‰, respectively.

The obtained isotopic curve shows five $\delta^{18}O$ negative trends or peaks. $\delta^{18}O$ values correlate with marine isotope stage (MIS) 28, 26, 24, 22 and 20 that occurred during the Matuyama chron (C1r.1r). This correlation indicates that climate changes influenced the isotopic signal of the studied nodules, that at the same time, partially correlate with facies changes. In this way, three of the obtained negative excursions correlate with facies changes towards wetter paleoenvironments (e.g. lacustrine episodes). However, not all facies shifts recorded in the Aalat section correspond to the $\delta^{18}O$ peaks. This fact suggests that climate is not the only responsible of the environmental evolution of the studied area.

SOURCE LAYER IDENTIFICATION OF LIQUEFIED SANDS EJECTED DURING THE BLAST-INDUCED LIQUEFACTION TEST AT MIRABELLO (FERRARA, ITALY) THROUGH A QUANTITATIVE COMPOSITIONAL STUDY

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It is well known that the occurrence of sand liquefaction phenomena may cause significant modifications of soil geotechnical properties and reduction of load-bearing capacity. Recent experiences (New Zealand, United States) have shown that liquefaction can be induced and monitored with field scale blast tests in order to study the related effects on soil characteristics. In this context the composition of sand blows represents an important tool to identify the liquefied layers. This study reports the composition of sands ejected during the blast-induced liquefaction test carried out in May 2016 at Mirabello (Ferrara, Italy). In 2012, the same area was largely affected by liquefaction phenomena during the Mw6.1 Emilia earthquake. Sand samples analyzed in thin section (34 samples, 300 points for each sample, fraction 0125-0.250 mm) include blast-induced sand blows, sands from 2 cores at different depths in the subsurface (from 2 to 20 m) and sands from 2 trenches in the blast site representative of 2012 liquefied sands. The sands from the cores show a clear trend from lithoarenitic to quartz-feldspar-rich compositions. The sands at shallow depth (up to 7 m) are the most lithoarenitic, with sedimentary fine-grained rock fragments (shales and siltstones) as the dominant lithic type. Lithic fragments derive mostly from the erosion of sedimentary terrigenous and carbonate successions of Apenninic affinity. These shallow sands are well distinguishable from the deeper sands (at depth > 7 m) that show compositions slightly enriched in quartz and feldspars and impoverished in lithic fragments that suggest affinity with the Po river sands. The composition of ejected sands largely overlaps that of the shallow Apenninic sands at depth from 6 to 7 m. Similarly, the sands from the 2012 dikes show a composition of Apenninic affinity compatible with that of the shallow sands. Results from the blast test fit well with data obtained from the study of the sands ejected in the nearby area of San Carlo during the Mw 6.1 earthquake. Also in this case, sand composition and fabric indicate that liquefaction processes affected mainly sand layers at relatively shallow depth (6.8-7.5 m). The study shows that composition of sands is crucial for a better understanding of earthquake-induced liquefaction mechanisms, in particular to identify the source layer of the sand blows and, more generally, for the recognition of critical levels prone to hazardous sand liquefaction phenomena.

LOADING AND FORELAND BASIN EVOLUTION DURING INVERSION OF INTERSECTING SALT-RICH RIFT SYSTEMS, CRETACEOUS TO OLIGOCENE, EASTERN PYRENEES

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Inherited crustal structure can have a profound effect on the distribution and style of deformation in foreland areas during orogenesis. This is well documented in the evolution of foreland basin geometry, subsidence and sediment sources. Here we describe the example of the eastern termination of the Aquitaine foreland basin in the easternmost sector of the North Pyrenees. In this area from Jurassic to early Cretaceous the NE-SW trending Tethyan passive margin was intersected by the EW Pyrenean rift system. During convergence of the Iberian and European plates from Santonian to Oligocene times, retro-foreland basin sedimentation records synchronous lithospheric loading from the east and south and changing sediment sources linked to the progressive inversion of the two salt–rich (Keuper) rift systems. The interference between the two inverting rift systems created the 60 km wide Corbières orocline that links the north vergent fold and thrust belts of the North Pyrenean Zone and the Pyrenean-Provencal zone to the NE. The thin-skinned Corbières nappe, long recognised as a gravitational nappe, was finally thrust from the E and SE over the foreland basin in the early Oligocene following an anticlockwise rotational trajectory. The kinematics and origin of the Corbières nappe have long been debated. Using foreland basin structure, growth strata, stratigraphy and sedimentation patterns we demonstrate that its emplacement was the final expression of synchronous inversion of the two rift systems from end Santonian (and possibly earlier) to Oligocene times. Loading from the east created N-S oriented depocentres that interfered with synchronous E-W depocentres created by loading from the south. Similarly, N-S compressional structures interfere with E-W compressional structures up to Oligocene times.

THE ROLE OF LARGER FORAMINIFERA IN THE EOCENE CARBONATE PRODUCTION: LARGE SHELLS VS. MICRITIC MUD

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Larger foraminifera (LF) are currently one of the most important carbonate producers in the shallow seas. In reef environments between 0 and 30 m the amount of $CaCO_3$ production by LF is close to 5% of the total, but if we look at all the shallow-water environments the sands are often composed by LF tests (40-98%). As pointed out by several authors, in the Eocene the abundance of LF has been more pronounced than in the modern seas. In contrast, the abundance of coral reefs is much reduced during the early Eocene “reef gap”. The observation of the overwhelming abundance of LF, probably due to their higher tolerance to rising temperatures and to their better fitness for lower pH of the sea, suggests they were globally the main carbonate producers of shallow seas, at least during the Eocene. Our investigation of the lower Eocene Bolca-Monte Postale *Fossil-Lagerstätten* (northern Italy) allowed to reconstruct an articulated mosaic ofpaleoenvironments, including coralgal buildups, Alveolina sands, and restricted ‘lagoons’ with micritic lime mud deposition. During the observations aimed to determine the different species of Alveolina useful for paleoecologic and biostratigraphic purposes, we noticed the tests of these LF are often broken and abraded, lacking the outermost whorls. Therefore, we started to consider the possibility that a significant portion of the lime mud accumulated in the ‘lagoonal’ facies could be the result of the mechanical destruction of the LF tests. This working hypothesis is supported by the observation that bioclastic sand bodies develop laterally to the bioconstructed coralgal rim and pass gradually to the evenly-bedded wackestones of the restricted basin of Monte Postale *Fossil-Lagerstätten*. The action of waves, currents, and tides could be the main cause of mechanical abrasion of the LF tests, as suggested by several hints of high hydrodynamic conditions both on the coralgal rim and in the Alveolina rudstone-packstone. Another possible source of micritic mud is the effect of the bioerosion: this was observed for instance in the lower-middle Eocene section of Bagnoli della Rosandra, near Trieste (northern Italy). Here extensive traces of biological activity, driving to the partial consumption of the Alveolina and Nummulites tests, are well visible in thin sections where most of the LF tests appear intensively bioeroded.

We are planning to perform geochemical investigation both on the LF tests and on the lime mud from the same localities in order to better understand the mechanisms leading to lime mud production of the Bolca fish-bearing laminites.

PALAEOENVIRONMENT AND PALAEOCLIMATE IN THE KUNGURIAN (EARLY PERMIAN) OF TREGIOVO (N-ITALY) FROM PALAEOBOTANICAL, PALYNOLOGICAL AND STABLE ISOTOPIC ANALYSES

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The Tregiovo Basin is a small sedimentary basin within the Athesian Volcanic Complex in the upper Val di Non (Trento Province, NE-Italy). It is intercalated between two volcanic formations respectively dated 274.1 ± 1.6 Ma and 276.5 ± 1.1 Ma, i.e., middle Kungurian. Abundant fossils such as conchostracans, palynomorphs, vertebrate and invertebrate footprints, and mostly plant fossils are known from this basin. The discovery of a new section, called “Le Fraine”, gave new insight on the Kungurian terrestrial paleoecology and palaeoenvironments. Three main lithofacies characterize the Tregiovo Formation. At the base and on the top, there are sandstones and conglomerates, whereas the middle part is characterized by very thin laminated siltstones/claystones, interpreted as organic-rich playa-lake and lacustrine sediments. The laminated siltstones/claystones are divided in two different lithozones, respectively a lower carbonate-free one and a middle carbonate-bearing part, with microbial carbonates. In the “Le Fraine” section two different levels from the carbonate-free laminated siltstones/claystones yielded rich plant assemblages: a lower one at ca. 35 m from the base of the section (Assemblages A) and an upper one from around 105 m (Assemblage B). Both assemblages consist of sphenophytes (*Annularia*), taeniopterids (*Taeniopteris*), seed ferns and ferns (*Sphenopteris*, *Peltaspermum*), ginkgophytes (*Sphenobaiera*) and are characterized by the dominance of conifers (e.g., *Hermitia*, *Feysia*, *Quadrocladus*, *Dolomitia*). However, conifers decrease from more than 80% in the lower Assemblage (A) to 60% in the upper assemblage (B). Vice versa, ferns/seed ferns, such as sphenopterids, are poorly represented in the lower assemblage and become quite common in the upper one (ca. 30%). Parallel to this, an increase of taeniate bisaccate and striate pollen is observed. The increase of ferns/seed ferns not necessarily indicates a change to more humid conditions, because the coriaceous and stiff appearance of the sphenopterids suggest a xeric affinity. Thus, the macroflora and the palynological assemblages reflect arid conditions. Another outcrop, located near the Village of Tregiovo, correlates with the upper part of the “Le Fraine” section, including the transition from the lower carbonate-free part to the middle carbonate-bearing one. A geochemical study on the $\delta^{13}C$ of bulk organic matter has been performed on the two sections. A clear trend towards more negative $\delta^{13}C$ values (VPDB) was documented. In particular, the $\delta^{13}C$ value of the lower assemblage is > 1‰ higher than the upper one. These results may reflect a change in the palaeoenvironmental conditions, e.g., increasing water stress. A similar global trend was observed. Whether the isotopic shift reflects changes in the floral composition (e.g., because the $\delta^{13}C$ differs between different groups of plants), local environmental changes or a global perturbation, could only be determined with further, taxon-specific geochemical investigations.

INSIGHTS IN THE SPATIAL AND TEMPORAL HETEROGENEITY OF BIOFILM LITHIFICATION THROUGH MULTI-SCALED X-RAY CT

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The role of microbes in the precipitation of carbonate minerals has often been discussed and precipitation mechanisms at multiple spatial dimensions still need to be unraveled. This study highlights the importance of multi-scaled X-ray computed tomography (CT) and 3D visualization at micro-and meso-scale combined with field (in-situ) and lab (in-vitro) experiments to understand the lithification of biofilms.

Two case studies have been selected showing how in-situ 3D visualization at multiple scales may unveil the pathway from crystal nucleation over crystallization to lithification. Mineralogy has been further identified using XRD (X-ray diffractometry) and TEM (Transmission Electron Microscopy). Correlative microscopy combining confocal laser scanning microscopy, SEM and micro-CT scanning made it possible to study the tight interaction between the cell wall, the biofilm (with EPS) and the (nano)-crystals during a first phase, and extensive lithification during a second early diagenetic stage. Samples have been measured with the Bruker Skyscan 2211 (multi-scale X-ray nano-CT system) using an open X-ray source (energies varying between 60 and 120 kV, < 4W) with Be-window. Two types of detectors have been used (resp. the 6 Mp flatpanel detector and the 11Mp cooled CCD detector) and voxel resolution was varying between 500 nm and 10 micrometer. Images have been reconstructed using InstaRecon. Image segmentation and visualization have been performed using resp. CT-An, CT-Vox and Avizo (FEI).

The first case study presents field precipitation experiments on different substrates of continental tufa deposits. Scanning and microscopy at different scales show that calcite starts precipiting within distinct layers and/or directly on the cell-wall of cyanobacterial filaments depending on the environ-mental conditions. The second case study visualizes microbial-mediated precipitates in biofilms from hypersaline lake environments, which have been progressively diagenetically altered under constrained lab conditions. Results evidence that nucleation of nano-crystals and primar crystallization processes are concentrated within the biofilm but that only during a second early diagenetic phase extensive lithification is taking over. This study highlights the necessity of high-resolution CT-scanning in combination with other microscopy techniques to understand the mechanisms and processes involved in the lithification of microbial mats.

LONG TERM EVOLUTION OF WET AVALANCHE IN WESTERN ALPS UNDER CLIMATE AND HUMAN FORCING

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Wet avalanches hazard may cause majors treat to human societies in mountain areas. In the context of fast cryosphere changes and their increasing number of observation in the last decades, it is crucial to better understand processes and environmental conditions favourable to their occurrence. Within the last 40 years, snow cover duration tends to decrease, whereas the number of wet snow avalanches in spring time is increasing. We focus this study on dense wet avalanches induced by entire snow pack destabilization, gliding on substratum and able to transport coarse detrital elements such as gravels and pebbles. The detection of avalanche deposits within lake sediment is based on the outlier presence of coarse grains within the fine sediment matrix. Classically, identification of those coarse grains was possible using wet sieving method but remains destructive and time consuming. In order to improve this technique, we used a novel CT scan methodology based on X-rays to precisely reference and quantify avalanche related grains in the lake sediment using medical imagery. In this study, we use the sedimentary archive of the mountain Lake Lauvitel (western French Alps), to establish the first long-term avalanche record in the Alpine region. In total, we identified 166 deposits over the last 3300 yrs cal. BP, including three high intensity events. Our results are supported by a palynological analysis highlighting the effect of vegetation cover on the avalanche hazard. Pollen record suggest a forested environment between 3300 to 780 yrs cal. BP. After this period, brutal changes in the pollen assemblage support a large deforestation event in the lake watershed. Moreover, this land cover change coincides with a major avalanche event dated at 760 yrs cal. BP and since then, we observe a significant increase in the avalanche occurrence. As anthropogenic pollen taxa are clearly increasing after the deforestation, we interpret this land cover change as a major forest clearance induced by human land use practices. Taking into account those changes, we investigated climate forcing on the avalanche hazard prior and after the forest clearance. Results show an avalanche frequency increase during periods of larger glacier extends such as the Little Ice Age (LIA) and the Migration Period (MP). Within these periods fluctuations of glaciers exists and phase of retreating ice cover seems to favor particularly avalanche hazard. On the last 350 years, we confronted our results with instrumental climatological data. Results exhibit higher avalanche occurrence while winter precipitation and spring temperature are both sufficiently important. We interpret those climatological conditions necessary to create large snowpack destabilization for wet avalanche to occur and transport coarse sediment to the lake. We highlight of both the influence of past vegetation dynamics and climatological conditions on the wet avalanche chronicle. In the context of actual climate warming, our results raise the question of whether the wet avalanche hazard increase may well be expected in the near future.

RISE IN ABUNDANCE OF SCHIZOSPHAERELLA SPP. AFTER THE S-P EVENT (SINEMURIAN-PLIENSBACHIAN, EARLY JURASSIC, SOUTHERN ALPS)

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The Sinemurian-Pliensbachian boundary Event (S-P Event, Early Jurassic) is a global negative $\delta^{13}C$ excursion that has been found in wood and marine carbonates, both in deep-and shallow water sedimentary environments, and is thought to reflect the injection of large amounts of CO_2 into the atmosphere-ocean system. The S-P Event coincided with major changes on carbonate platforms. On the Trento Platform, which was located in the northwestern Tethys, a major change from a microbialite-dominated carbonate factory to one dominated by skeletal grains occurred across the negative carbon-isotope perturbation. This change was attributed to a crisis of the factory possibly due to a wet climate phase associated with increased terrigenous input and the onset of meso-eutrophic conditions. If and how the S-P Event might have influenced deep-water marine environments was instead not investigated yet. A thick succession of cherty limestone that deposited in deep waters in the Lombardian Basin, west of the Trento Platform is exposed in the Tofino section, in the central Southern Alps. Investigation of these rocks shows that in the Sinemurian nannoplankton was scarcely diversified and rare, with most of the pelagic carbonate given by the "calcisphere" *Schizosphaerella* spp. Point counting and supervised image classification techniques were carried out on SEM images in order to estimate the percent contribution of carbonate represented by Schizosphaerella spp. to the bulk rock volume. Results show that this contribution was low (< 10%) until after the S-P Event, when the percentage of Schizosphaerella rose above the 40%. Similar increases in the abundance of calcispheres were documented after the Mid-Carnian and Early Toarcian global carbon cycle perturbations. In the case of the Toarcian, this was interpreted as the response to nutrification event and rise of atmospheric CO_2 levels by accelerated planktonic biological and carbonate pumps. Therefore, results of the investigations of the Tofino section envisage a possible connection between the S-P Event perturbation of the carbon cycle, the crisis of shallow water carbonate factories and the sudden rise in pelagic carbonate production. In conclusion, data presented in this contribution may help shed light on one of the major changes that occurred in the Early Jurassic oceans, when the spread and diversification of calcareous nannoplankton brought it to progressively become a fundamental contributor to carbonate production in open ocean settings and a major actor in the global carbon cycle.

ARCHEAN STROMATOLITES FROM THE LOWER TRANSVAAL SUPERGROUP (BOTSWANA): PRISTINE GEOCHEMICAL SIGNATURE VS LATE DIAGENETIC OVERPRINT

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The geochemical composition of carbonates is considered a reliable proxy for the investigation of Precambrian oceans and early life on Earth. Nevertheless the evaluation of the effects of diagenesis on the pristine composition of ancient carbonates has proven to be challenging.

Here we used laser ablation–inductively coupled plasma–mass spectroscopy (LA-ICP-MS) for the in situ measurement of trace elements in ca. 2.6 Ga stromatolitic dolomite of the Lower Transvaal Supergroup in the Kanye Basin (Botswana). These dolostones have been deposed within a shallow marine carbonate platform extended from Zimbabwe through the Kanye Basin and to the main Transvaal Basin in South Africa. In the Kanye Basin these platform sediments fall under the Taupone Dolomite Group (TDG). The sedimentary rocks in the study area have been affected by the circulation of hydrothermal fluids during the emplacement of the Moshaneng Complex (1.9-2.1 Ga).

The aim of this research is i) to unravel the effect of hydrothermal fluids circulation and diagenesis on the pristine signature of stromatolites; ii) to characterize the palaeoenvironmemt condition and the sea water composition during the Archean on the Kaapval Craton.

Outcrops description revealed the existence of 5 types of dolomite based on the stromatolite content: massive dolomite, stratified stromatolite, large stromatolites, columnar and domal stromatolite. The carbonate sequence records a deepening upward trend as suggested by the transition from massive to laminated dolomite to columnar stromatolite to domal stromatolites. The dolomite sequence grades into oolitic dolomite and cherty dolomite. Three different stromatolite facies (large, stratified and columnar) and the oolitic dolomite have been analysed for their major and trace elements content through ICP-MS and LA-ICP-MS. Five carbonate microfacies have been described: i) spatic dolomite; ii) microcrystalline dolomite; iii) spatic dolomite with quartz patches; iv) rhombohedral dolomite; v) oolitic dolomite.

Preliminary geochemical analyses revealed an abrupt decrease in ∑REE contents from stromatolitic dolomite to oolitic dolomite. The decrease of ∑REE content is correlated with the increase of Y/Ho ratio, from near-chondritic values (ca. 32) toward a normal-marine super-chondritic ratio (ca. 63). The REE patterns of dolomite appear quite homogeneous across the different stromatolite facies with a sensible increase in REE composition in the columnar stromatolites. All samples lack Ce anomaly and show a rather flat REE pattern. A slightly positive Eu anomaly has been detected in the rhombohedral dolomite suggesting a possible interaction with hydrothermal fluids at late stage of diagenesis.

These preliminary data suggest that: i) higher ∑REE contents within stromatolites is probably due to microbial scavenging of REE; ii) oolitic dolomite has been deposed in a shallow lagoon, the low ∑REE contents coupled with super-chondritic Y/Ho ratio reflect a normal-marine trend. Preliminary data also reveal that, although pristine micro-fabrics might have been altered during late diagenesis, the effect of hydrothermal fluids circulation did not obliterate the pristine geochemistry of the carbonates.

DESERT SPRING MOUNDS: NEW INSIGHT ON THE RESILIENCE OF LIFE

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Microbial carbonates provide records of Earth's life since at least 3 Ga, and show adaptation of life to extreme arid environments, which makes their study crucial in gaining understanding of life's evolution and its limits on Earth and beyond. Desert spring mounds carbonates have the potential to provide insight into the nature of life/rock interactions. The desert environment challenges our notion of life-supporting systems, as microbial mounds occur at the resurgence of alkaline ground-waters. These microbial carbonates from hyperarid settings provide unique information on bio-mediated crystallization pathways that results in "bizarre" crystal morphologies and trace element, including REE enrichment. Similarly to other continental bio-mediated carbonates, desert spring mounds exhibit micrite and microsparite layers suitable for petrographic and geochemical investigation at micro-to nano-metre scale.

Crucially, non-classical nucleation favored by organic compounds, and growth through epitaxial addition of nanoparticles on aggregates seem to help preserving a "primary" or "quasi primary" signal. Here, we investigate the role of microbial communities and/or by-products of microbial activity in the formation of desert spring mounds. We propose classical sedimentological, chemical and geomicrobiological characterization of spring carbonates from the Great Artesian Basin (GAB) in South Australia and from the Makgadikgadi Pan (MKP) in Botswana coupled with cutting edge Electron Microscopy analyses.

Along the western margin of the GAB, where groundwater reaches the surface, microbialite, travertines and phytoherm framestone tufa occur. Preliminary data reveal that layering of carbonates may reflect a change in the mineralization, and, likely, changes in the influence of microbial activity. Detailed micro-and nano-structural study of these carbonates sheds light onto both bio-mediated and inorganic processes conducive to the formation of microbial mounds. The present research commenced by scrutinizing the "field" scale morphologies of the mounds. Samples of carbonate sediments have been investigated for their mineralogical composition by XRD. Standard optical microscopy and SEM-EDS revealed that microbial carbonates mostly consist of wind dust, carbonates and evaporite minerals, precipitated by cyclical upwelling of saline groundwater. GAB mounds are similar to the less well known MKP mounds from arid Central Botswana. In this extreme desert environment, groundwater discharge sourced in the Okavango area is associated with mounds that had previously been interpreted as wind dunes, and only recently as evidence for a cyclical groundwater upwelling potentially conducive to microbial bio-mediated precipitation of salts. During the dry season the surface of the Makgadikgadi pan becomes extensively salt encrusted providing a scenario similar to Lake Eyre along the western GAB. Whilst the GAB mounds are unequivocal evidence of microbial processes, there is still not enough evidence that the MKP mounds are the manifestation of microbial life.

Preliminary results from recent evaporative settings suggest that growth occurs through nanocrystal aggregation into mesocrystals and, upon early diagenesis, micrites. This suggests that chemical signals of microbialites are likely to be inherited by the process of aggregation and subsequent early diagenesis, and, therefore, we conclude that early diagenesis preserves for billions of years the original environmental parameters.

EARLY DIAGENESIS OF CARBONATES ON POLAR SHELVES

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Early seafloor diagenesis exerts a strong role in determining the preservation and appearance of the deposits of carbonate depositional systems in the rock record. Marine eogenetic processes have long been understood in the tropical realm and recent investigations have extended understanding into the temperate realm. There has been comparatively little integration of seafloor diagenetic processes in high latitude settings. This study integrates petrography and isotope geochemistry to document the effects of marine eogenesis on Quaternary carbonate deposits that accumulated on the Ross Sea Shelf, Antarctica. Ancient analogs provide context for considering the effects of early marine diagenetic pathways on preservation of cold-water carbonate deposits. The outer shelf of the Ross Sea is home to a carbonate factory that has been active sporadically over the past 40,000 years, with radiocarbon dating indicating a major phase of accumulation during ice sheet expansion in the latter part of Marine Isotope Stage 3, a hiatus during the Last Glacial Maximum, and renewed production within the last 3000 years. An older phase of deposition (c. 1 Ma) is known from a drillcore (CRP-1) taken near the margin of the Transantarctic Mountains. Petrographic analysis reveals that calcareous components are dominantly calcitic. The presence of aragonite producers in the living carbonate community suggests that their relative paucity in sediments records taphonomic loss via dissolution. There is little to no petrographic evidence that grains have undergone either dissolution or neomorphism. In addition, calcite cement is absent, although authigenic phosphate minerals are locally present in intraparticle pores. These observations are supported by isotopic data, which show no evidence for alteration of primary signatures. By far the most prominent eogenetic processes are related to biological activity, including grain encrustation by bryozoans, foraminifera, and serpulids and endolithic boring by worms, sponges, fungi, and microbes. The degree of boring is variable stratigraphically, with specimens from some intervals largely unaffected and specimens from others showing evidence of repeated infestation. Because heavily bioeroded grains show evidence of reworking, these patterns are interpreted to reflect variations in accumulation rate and residence time on the sea floor. Unlike their tropical cousins, endolithic borings in Ross Sea carbonate grains remain empty, serving to increase grain susceptibility to disintegration. Observations indicate that these sediments, essentially taphonomic remnants, will enter the geologic record as unconsolidated deposits with very low diagenetic potential and features that reflect the accumulated effects of primary depositional conditions and a potentially lengthy period of alteration on the sea floor. Comparison with ancient analogs indicates that lithification will likely be delayed until deposits reach burial depths at which chemical compaction proceeds. The ultimate end product will be limestones with tightly packed fabrics. Skeletal carbonate might retain primary geochemical compositions. In providing a cold-water end member for the spectrum of marine eogenetic processes, results highlight specific differences that should be accounted for when interpreting the deposits of warm, cool, and cold-water carbonate systems.

AMMONITE AGE-CALIBRATION OF THE URGONIAN-TYPE LIMESTONES FROM PROVENCE (SE FRANCE) AND ITS BEARINGS ON THE TIMING AND DRIVING MECHANISMS OF NORTH TETHYAN PLATFORMS DEMISE

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During Barremian-Aptian times, the Urgonian-type Provence platform (SE France) records its maximum northward progradation from the south (Calanques Massif) to the north (Monts de Vaucluse) with the installation and spreading ofthree rudistid units (U2 unit sensu lato); from oldest to youngest, the Agriopleura, requieniid-monopleurid and caprinid biofacies, sandwiched between two bioclastic cherty formations (U1 and U3 units). This work provides a new ammonite-age calibration of the rudistid limestones from Provence based on new in-situ ammonites sampling along three ~100 km-long platform-to-basin transects and the re-examination of historical collections. Ammonite key findings indicate that the northward progradation initiated in the lower part of the *Gerhardtia sartousiana* Zone and collapsed at the top of the *Martelites sarasini* Subzone (lower *M. sarasini* Zone). A major trophic change, evidenced by orbitolinid mass accumulation occurred during the *I. giraudi* Zone and the base of the *M. sarasini* Subzone. The overlying U3 unit includes ammonites dating the base of the uppermost Barremian *Pseudocrioceras waagenoides* Subzone (upper *M. sarasini* Zone) and the Lower Aptian *Deshayesites oglanlensis-Deshayesites forbesi* (pars) zones interval. The regional demise of the caprinid biota is therefore of latest Barremian age and it has no link with the spreading and culmination of the Lower Aptian OAE 1a, whose litho-and biological markers have been previously recorded in the post-Urgonian marly cover. Re-examination of the literature supports a quasi-synchronous collapse of the North Tethyan Urgonian carbonate platforms in the uppermost Barremian; an age which challenges the unfolding oceanographic events of the OAE 1a as the main driving mechanisms involved.

OCEAN CIRCULATION DURING THE LATE CRETACEOUS: INSIGHTS FROM ND ISOTOPE VALUES OF FISH REMAINS AND CARBONATES ON THE SOUTHERN TETHYAN MARGIN (LEVANT PLATFORM, ISRAEL)

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The Latest Cretaceous is marked by extensive deposition of phosphorites and organic-rich sediments on the southern Tethyan margin. The occurrence of these deposits has been linked to the development of upwellings, possibly associated to an intensification of the Tethyan Circumglobal Current (TCC). Yet there is currently no direct evidence of the presence of these upwellings, apart from the occurrence of microfossil assemblages associated to high primary productivity. In this context, our study aims to track changes in water masses on an area of the southern Tethyan margin that recorded phosphorites, organic-rich deposits, and high productivity microfossil assemblages, through the evolution of local seawater neodymium isotope composition (ϵNd).

Fish teeth from about 25 different levels were recovered within the Turonian to Maastrichtian interval on the Levant Platform in the modern Negev desert of Israel and analyzed for their ϵNd and rare earth element (REE) composition, along with 32 carbonate leachates from a core drilled in northern Israel (RE-6 core). Rare earth element composition and ϵNd of RE-6 core sediments residues have additionally been determined (< 2 µm fraction of the sediment remains after carbonate removal by acetic acid leach, Fe-Mn oxide removal by hydroxylamine hydrochloride leach, and organic matter removal by oxygen peroxide). The carbonate leachates display REE pattern similar to seawater, and yield comparable ϵNd values and trend than those displayed by the fish teeth from the Negev. This similarity points to a local seawater origin for both records. The new data highlight a decrease in local seawater ϵNd from quite radiogenic values of about -3.5 ϵ-units in the Coniacian to minimum values of -6.5 ϵ-units in the Early Campanian. Local seawater Nd isotope values then increase prior to the main phosphorite unit to reach a maximum of -4 ϵ-units within the phosphorite level, and then decreased again down to -6 ϵ-units in the Maastrichtian. The ϵNd values of the residues are much less radiogenic, ranging from -11 to -6 ϵ-units, except in the phosphate-rich interval where they become closer to the values displayed by fish teeth and carbonates. Based on REE pattern of the residues, we interpret this evolution as reflecting the existence of a seawater Nd signal still present in the residue fraction, possibly from remaining phosphatic material that would not have been removed by the sequential leaches. The increase of local seawater ϵNd depicted in the fish teeth and carbonate leachates is then interpreted as the establishment of intense upwellings on this part of the southern Tethyan margin and/ or as increased inputs of surface waters from the Pacific linked to a more active TCC.

OBLIQUITY FORCING ON MOISTURE SUPPLY AND ECCENTRICITY CONTROL ON WATER BUDGET: A CENTRAL ASIAN PERSPECTIVE ON THE MIOCENE CLIMATE TRANSITION

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Despite overall desertification in Central Asia during the Cenozoic, a period of elevated moisture transport into Asia's continental interior is evident by widespread occurrences of Miocene lacustrine sediments. In this study, we present data from the Aktau Hills, Ili Basin in SE Kazakhstan. The 370 m thick Aktau section exhibits cyclical deposition of sediments covering a wide facies range from mudflat to lacustrine environments. Therefore, our record is an exemplary archive for sedimentary response to climate fluctuations. Age constraints are deduced from an integrated approach of magnetostratigraphy, cyclostratigraphy and U-Pb dating of lacustrine carbonates. Accordingly, the Aktau section spans a period from 15.5 Ma to 11.0 Ma, including the Miocene Climate Transition (MCT).

Onset and climax of the Miocene Aktau palaeo-lake are reflected by an environmental shift from a dry mudflat to a perennial freshwater lake with a transitional high salinity phase. A facies model and thin section observations enable the differentiation of six syn-sedimentary water levels and four evaporation stages.

In applying this model to the detailed lithological log, two-time series reflecting variations in water level and evaporation (=salinity) are generated.

Time series analysis suggests significant climate forcing on orbital time scales. The water level of the palaeo-lake and its precursor mudflat shows an extensive dependency on the approximately 400 ka and 100 ka eccentricity cycles. Eccentricity and water level have an inverse phase relation. Evaporation seems to be linked to the 1.2 Ma period in amplitude modulation of obliquity. Phases of elevated salinity are developed at times of low amplitude oscillation of obliquity (=nodes) and vice versa.

The variations in eccentricity are likely to account for changes in the regional water budget. We infer that, water level highstands occur during eccentricity minima due to lower summer insolation and thus lower summer evaporation. Consequently, winter precipitation exceeds summerly evaporative water loss resulting in a lake expansion. Nodes and phases of high amplitude oscillations in obliquity seem to have opposing impacts on atmospheric moisture transport to Central Asia.

In conclusion, the development of the Aktau palaeo-lake can be regarded in the light of global cooling during the MCT. Particularly, the interval from 14.6 Ma to 12.8 Ma, showing the highest cooling rates, coincides with the major saline phase in the Aktau section. The establishment of the lake took place within the same time frame with stepwise flooding paced by the ~400 ka eccentricity cycle.

TRACKING WATER LEVEL AND EVAPORATION ON BASIN-SCALE: A DETAILED FACIES MODEL FOR THE LACUSTRINE MIOCENE DEPOSITS OF THE ILI BASIN, SE KAZAKHSTAN

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The Miocene is characterised by an episode of lacustrine sedimentation in several Central Asian basins. Our study focuses on two sections from the Ili Basin, SE Kazakhstan, which recorded the successive lake establishment in a proximal (Kendyrlisai section, 59 m thickness) and distal (Aktau section, 370 m thickness) setting. Biostratigraphic data suggest a Middle to Late Miocene age for the Aktau section. Shorttermed cyclic oscillations of facies zones, along with the long-term basin flooding, make the Aktau section an exemplary archive for a wide range of terrestrial environments. Furthermore, implications of proximaldistal relations on the depositional environment can be outlined.

A facies model comprising 18 facies zones has been developed to rank facies changes. It is able to differentiate between six relative water levels and three different stages of evaporation. Applying the facies model to the lithological logs gives a relative quantification of water availability and salinity. Combined and simplified to four depositional environments, water level and evaporation stage help to visualise facies associations (FA).

It has been possible to correlate the sections over a lateral distance of 35 km. Common marker beds of prominent base-level highstands can be recognised in FA A (dry mudflat) and B (subaerial playa environment) of both localities. The beginning of FA B is characterised by a coeval establishment of high evaporation conditions up to anhydrite precipitation. We interpret that the Ili Basin had a flat relief during times of FA A and B.

Later on, FA C (intermittent saline lake) is only developed in the basin centre, whereas water levels in the proximal section remain at mudflat level. A subsequent basin-wide base level rise marks the end of evaporite precipitation. However, only short-lived highstands from the perennial freshwater lake in the basin centre reached the proximal mudflat areas. A relief steepening is likely to cause this separation of the formerly common depositional environment across the basin.

After a drastic regression, the water level oscillates with high amplitudes around littoral lake conditions in the Aktau section (FA E). This suggests a flat relief again, possibly due to successive progradation of proximal lake facies zones.

In summary, the water level development shows, unlike the trends in evaporation stage, a strong dependency on spatial relations within the basin. Changes in evaporation are more likely linked to regional climate fluctuations.

ARCHITECTURE, EVOLUTION AND DEPOSITIONAL CONTROLS OF A LATE HOLOCENE HYPERTIDAL RECURVED BARRIER-SPIT SYSTEM

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Understanding barrier spit formation and evolution is increasingly important in order to assess how these soft-sediment coastal systems will respond and adapt to expected future environmental changes. Barrier spit development is the result of complex multiscale interactions between wave and tide dynamics, fluctuations in sea level, storm impact and sediment supply along with geological and morphological inheritance. The stratigraphy and internal architecture of barrier systems preserve information about the dominating processes and controls that governed past coastal evolution. In coastal areas with relative high levels of tidal energy and low levels of wave energy, tide-dominated deposits preferentially make up the sedimentary record and wave-dominated deposits are rarely preserved. Hence, these systems are often considered to hold little or no information of past changes in wind and storm climate.

In this study we investigate a Holocene recurved barrier spit situated along the west coast of the Cotentin Peninsula in the English Channel, France. This coast is subject to a tide-dominated energy regime with a tidal range exceeding 14 m and a mean significant wave height of less than 0.5 m. Integrated analysis of core and ground-penetrating radar data suggest that the barrier spit has a complex sedimentary architecture consisting of tide and wave dominated sedimentary bodies.

We present a new sedimentological model for recurved barrier spit development under hypertidal conditions. The model describes how the spit extents downdrift by clinoformal progradation resulting from littoral drift caused by longshore sediment transport and due to swash bar welding along the distal end of the barrier. Lateral and vertical growth of the spit terminus results from sediment convergence due to landward migration of swash bars and seaward migration of tidal dunes.

Radiocarbon and optically stimulated luminescence datings reveal that spit evolution and progradation probably occurred in two stages from about 900 to 1200 years ago and from 300 to 400 years ago. We suggest that increased windy conditions during the Little Ice age and resulting increased littoral drift may be responsible for the latter period of spit progradation.

SEQUENCE SUBDIVISION AND DEVELOPING CHARACTERISTICS OF LOW-ACCOMMODATION NONMARINE BASIN, A CASE STUDY OF YANCHANG FORMATION IN THE ORDOS BASIN

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The third-order sequences of the Yanchang Formation in the Ordos Basin were determined by comprehensive analysis of surface outcrops, core, logging, and seismic data. Natural gamma curves were studied by the method of band pass. Furthermore, the hidden stratigraphic sequence and the six lithological cycles were extracted. By determining sequence boundary and lithological cycle, we identified six third-order (including SQ1, SQ2, SQ3, SQ4, SQ5, and SQ6) and three second-order sequences in the Yanchang Formation. And the sequence stratigraphy of the Ordos Basin had the following special developing characteristics: 1) The third-order sequence growths were totally stable, and the thickness of the Ordos Basin was relatively stable; 2) Thick sand bodies did not form in lowstand systems because of underdeveloped slope breaks; 3) The third-order sequences had diverse features at different sedimentary periods; 4) The distribution of the depositional systems had various characteristics in different tectonic plates; and 5) the entire sequence had the filling characteristics of multiprovenance and multicycle. Moreover, the study indicates that controlling factor of third order stratigraphic sequences of Yanchang Formation in low-accommodation lacustrine Ordos basin includes sediment supply (provenance), climates and fluctuation of lake level. In general, this case study indicates the developing characteristics and controlling factors of sequence stratigraphy in low-accommodation lake basin, pro-vides a comprehensive method to establish sequence stratigraphic framework of low-accommodation non-marine basin, and predicts that SQ3, SQ4 and SQ5 of Qiaochuan and Zhidan areas are favorable for oil and gas prospecting of Yanchang Formation in Ordos Basin.

SEDIMENTARY FACIES AND HYDROCARBON RESERVOIR OF WULAN-HUA SAG, ERLIAN BASIN

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Based on the well logs, geochemical data and 3-D seismic data, the aims of this study includes sequence stratigraphic framework establishment, sedimentary facies delineation, sediments partition and favorable reservoirs prediction in Wulan-hua Sag, southern Erlian Basin, northern China. The results are as follow: 1) Six 3rd-order sequences (SQ1, SQ2, SQ3, SQ4, SQ5, and SQ6, respectively) have been recognized; 2) The fan-delta derived from multi-directions provenances develop in the A4 member. Based on the paleogeomorphological reconstruction, the sand-rich sediments mainly transported from four directions including west, east, southwest, and northeast, distribute to the deep-lake environment in the northern part of the study area, which is controlled by the underwater paleo-uplift. 3) The high quality sandy reservoirs of gravelstone and sandtstone develop in the T1 member. The favorable hydrocarbon exploration targets in the A4 member locate in the region of the northwestern part of Well Lan 5-Well Lan 42 and southern area of the center sag. The favorable reservoir prediction has guidance to further petroleum exploration in Wulan-hua Sag. This case study provides an example to the analysis of sequence stratigraphy and sedimentary system in lacustrine rifted basins.

SEDIMENTOLOGICAL EVIDENCE FOR RECENT TECTONIC ACTIVITY IN THE INTERANDEAN CAUCA RIVER CANYON (WESTERN COLOMBIA)

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Recent seismic activity can be expressed by different forms of tectonic deformation in nonconsolidated fluvial-lacustrine and debris-flow deposits. We study such deposits along the Interandean Cauca River Canyon in western Colombia as a proxy for paleoearthquakes related to the recent activity of Sabanalarga Fault System (SFS). We specifically focus on the east bank of Cauca River throughout the SFS, which is one of the most prominent active faults in western Medellin city. Our aim is to evaluate the recent tectonic activity through three complementary aspects: (1) regional compilation of historical seismicity recorded in chronicles, (2) morphotectonic mapping of the surface traces that compose the SFS and, (3) paleoseismological assessment of two trenches (Rodas and Olaya) with evidence of recent (Late Pleistocene to Holocene) faulting and liquefaction.

The Rodas trench consists of a 12 m thick fluvial sequence composed of a bundle of gravels, and coarse laminated sands. The deformation is mainly expressed by extensional faulting with reverse and normal offsets, tilting, fracturing and micro-faulting of the sand packages along with liquefaction-dikes structures. The Olaya trench is composed of a fluvial-lacustrine sequence up to 20 m thick of well classified laminated silty sands of the Cauca River intercalated with gravels from debris-flow deposits from the tributary streams. A diversity of decimetre to millimetre-scale soft-sediment deformation structures are observed in the Olaya trench as well as positive flower structures, compression of the sediments package along with conjugate normal faults at the edges of the sequence.

Radiocarbon dating of charcoal reveals a minimum age of 2900 cal yr BP for the tectonic deformation at Olaya trench. Moreover, by the means of the assessment of eight IRSL and OSL samples in both trenches, preliminary results suggest that deformation might be as old as Late Pleistocene (< 100 kyr BP). On the basis of paleoseismological evidence and sediment deformations, at least one seismic event, perhaps coupled to the SFS, has been identified in both trenches. Using empirical relationships of attenuations of seismic energy, an earthquake with a Richter magnitude from 6.6 to 7.0 can be estimated according to the maximum measured of the apparent vertical displacements at the trenches (40 and 80 cm in Olaya and Rodas respectively).

These findings at 50 km distance of Medellin city with a population for 4 million may have strong implications on how government entities consider the seismic hazard in the region. Additionally, the Ituango Dam is being built 60 km upstream from the study area, which will be the most important hydroelectric dam of Colombia. Therefore, it is necessary to consider local earthquake sources, which we could only assess through paleoseismology, as instrumental and historical seismic records are not providing a long enough temporal coverage.

CONTINUOUS SPECTRUM OF SEDIMENT-DENSITY FLOW DEPOSITS OBSERVED ALONG COARSE-GRAINED, MEDIUM-SIZED BASIN MARGIN CLINOFORMS, JURASSIC NEUQUÉN BASIN, ARGENTINA

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Sedimentary density flow transformations and associated deposits are key elements in basin margin construction, however, while basin margin clinoforms are usually visible in seismic sections, detailed analysis of sedimentary facies and stratigraphic architecture of sediment density flows is only available from outcrops. Cliniforms (300 m high) from the southern Jurassic Neuquén Basin, Argentina (La Jardinera area) show a well-exposed shelf to deepwater succession from the fluvial and shelfal areas to the upper slope, lower slope and basin floor, and provide a unique opportunity to study both seismic scale clinoforms and millimeter-scale sediment density flow transformation deposits that have accumulated on and bypassed the clinoform. Upper-slope conglomerate and coarse-grained sandstone facies are found in incised canyons kilometers long and a hundred meters thick, showing the characteristics of sandy debrites and high-density turbidites with poor sorting and occasional inverse grading. Lowerslope channels are one order of magnitude smaller than the upper-slope canyons, and are filled with amalgamated, tabular bedded, fine to medium-grained, normally-graded low-density turbidity deposits. Pebble-sized conglomeratic debrite and coarse-grained high-density turbidite sandstone re-occur in the basin floor fan deposits, and in 'channel-lobe transition zone'. The described facies of sediment density flow deposits and deepwater element architecture strongly point to multiple flow transformations across the shelf margin, and various mechanisms controlling sediment bypass and basin margin evolution. The sediment delivered to the slope channels was supplied by a periodically flooding, gravel-sand mixed river-delta system across a narrow (< 40 km) shelf. The river derived coarse-grained sediments delivered to the shelf break became sandy debrites and high-density turbidites within upper slope canyons, possibly due to the high sediment-concentration during river flooding and/or shelf margin collapse after deposition at the shelf edge. The low-density turbidite forming the lower-slope channel fills may be the result of the transformation of upper-slope coarse-grained sediment density flows into low density turbidites due to (1) gradual deposition and increasing ambient water entrainment, or (2) reworking by turbidity currents of unconsolidated coarse-grained deposits on the upper slope. Either way, the two flow transition mechanisms partition coarse grains to the upper slope channels and finer grains to the lower slope, and both mechanisms contribute to construction of the shelf margin slope. In contrast, the presence of conglomerate and coarse-grained sandstone facies on the basin floor suggests high rates of sediment bypass of the slope and deposition due to gradient reduction and flow deceleration, thus building the bottomset of the basin margin clinoform. Some of the coarse-grained deposits in the channel-lobe transition zone are associated with significant soft sediment deformation (e.g. meter-scale flames) of the underlying sandy substrate; similar facies elsewhere have been linked to hydraulic jump in turbidity currents signaling another flow transformation triggered by gradient decrease on the basin floor. Thus clinoforms of the La Jardinera area of southern Neuquén Basin provide key facies resolution to characterize a broad spectrum of sediment density flow deposits, and thus discern possible flow transformations involved in the construction of shelf margins and infilling of basins.

GEOMORPHOLOGY AND SEDIMENTARY SEQUENCE EVOLUTION DURING THE BURIED STAGE OF LARGE-SCALE PALEOUPLIFT WITHIN HINTERLAND AREA OF THE BASIN: A CASE STUDY OF LOWER CRETACEOUS QINGSHUIHE FORMATION IN JUNGGAR BASIN, NORTHWESTERN CHINA

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The evolutionary processes of large-scale paleouplifts within sedimentary basins have significant control over the sedimentary sequence, provenance and depositional systems. The lower Cretaceous Qingshuihe Formation (K1q) within hinterland area of Junggar Basin is a distinctive sedimentary sequence developed during the buried stage of large-scale Chemo paleouplift which had been suffered more than 20 million years of erosion and weathering. This research, aiming to restore changes in paleogeomorphology, interpret sedimentary sequence evolution and unravel detailed sedimentary facies, is based on the integration of outcrop and core analysis, grading data, drilling well logs and 3-D seismic data interpretations.

Due to the long-term differential river incision/erosion and weathering processes in arid conditions during Jurassic, the paleouplift finally changed into a distinctive valley-monadnock paleogeomorphology prior to the deposition of K1q. The K1q is a complete third order sequence and can be further subdivided into lowstand, transgressive and highstand systems tracts (LST, TST and HST). Significantly controlled by the paleogeomorphology, LST is confined within incised valleys and is mainly composed of gravelly braided rivers and randomly occurring debris flows adjacent to the valley margin; TST extensively developed in a nearly flat landform and evolved from braided river delta to the final lacustrine depositional systems, however, in period of HST, the hinterland area of the basin was covered by the sheet-like prograded delta systems. Specifically, two types of sequence stratigraphic framework which are controlled by the paleogeomorphology can be identified in the study area. Namely, in addition to LST braided river conglomerates overlie the sequence boundary within valleys, TST delta sandstones or lacustrine siltstones/mudstones can also directly cover the sequence boundary on highland areas of the monadnocks. The onlap LST coarse sediments gradually filled in the gaps of the paleotopography, resulting in the coincidence of first flooding surface with the sequence boundary at the top of monadnocks and a parallel relationship between first flooding surface and maximum flooding surface.

The sedimentary sequence evolution model is established and shows that the depositional processes during the buried stage of the long-term eroded paleouplift are directly controlled by the base level/lake level, and are totally influenced by multi-factors, namely climate, tectonics, sediments supply and geomorphology. Since the early Cretaceous, tectonic subsidence and humid paleoclimate conditions resulted in the rise of base level/lake level, accompanied with an increase in river discharge and sediments supply. Thus, extraformational deposits of LST braided river and TST braided river delta gradually filled an inherited valley-monadnock paleogeomorphology and, finally, the paleouplift areas were drowned by lacustrine water and turned into the uniform depression.

THE ORIGIN AND ALTERATION OF CALCITE CEMENT OF SHISHUGOU GROUP SANDSTONES IN THE FUKANG SAG, JUNGGAR BASIN, CHINA: IMPLICATIONS FOR FLUID-ROCK INTERACTIONS AND POROSITY EVOLUTION

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The Shishugou Group comprising Toutunhe Formation of Middle Jurassic and Qigu Formation of Upper Jurassic, is currently an important hydrocarbon exploration target in the Fukang Sag of Junggar Basin, China. The Shishugou Group sandstones experienced complicated diagenesis and belong to low-ultralow porosity and permeability reservoir with deep burial (3600 m-5800 m), but some high quality reservoirs have been found due to the reservoir heterogeneity in the tight sandstones.

Calcite cement, which is dominated cement with strong heterogeneity, exerted remarkable control on reservoir quality in the Shishugou Group sandstones. The calcite cement has been studied by a variety of methods, including core and thin section observations, X-ray diffraction (XRD), scanning electron microscope (SEM), Cathodoluminescence (CL) imaging, electron probe analysis and isotopic analysis of C and O. This integrated petrographic and geochemical study aimed to unravel the origin and alteration of calcite cement, and help to understand and predict fluid-rock interaction and porosity evolution. The main conclusions of the study are that the intergranular pores of are locally and completely occluded by calcite cements without iron. Diagenetic calcite consists of two generations: early generation extensively occurred as poikilotopic, pore-filling masses (forming an interlocking mosaic of crystals), the small amount of late generation occurred as isolated rhombs or partial grain replacements.

The slight – medium saline lake water with high salinity of semiarid-arid climatic Shishugou Group, provided the alkaline diagenetic environment needed for precipitation of chlorite and early calcite cements at the early diagenetic stage. The Ca^{2+} of the pore-filling calcite cements was sourced from weathering or dissolution of volcanic rock fragments in the provenance or the process of transport in the oxidizing condition. The δ^{18}OV-PDB values and δ^{13}CV-PDB isotopic compositions of the calcite cement were significantly controlled by the top unconformity and coal-bearing stratum (J2x). The pore-filling calcite cement in Qigu Formation sandstone mainly precipitated from diagenetic fluids of mixed major meteoric water with CO_2 (δ^{13}CV-PDB values is -7‰) and minor organic matter (organic acid and CO released by the coal-bearing stratum with the δ^{13}CV-PDB values of -23‰ ~-8‰). On the contrary, the pore-filling calcite cements of Toutunhe Formation sandstones are sourced from major organic matter and minor meteoric water with CO_2. The increasing organic acid changed the diagenetic environment, and sharply dissolved the early calcite, analcime, feldspar and volcanic rock fragment at middle-late diagenetic stage. The dominant calcite cement enhanced the reservoir heterogeneity by cementation and heterogeneous dissolution. However, the early carbonate cement inhibited burial compaction and then produced intergranular pore space and improved reservoir physical property by late dissolution under acid conditions. Anhydrite cement is the symbol to the transformation of organic acid and hydrocarbon and generally close to migration pathway of fluid. The second hydrocarbon charging benefit preservation of reservoir porosity. The fluid-rock interaction and porosity evolution now can be predicted by confirming the origin and alteration of calcite cement.

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TIDES AND WAVES INFLUENCE VARIABILITY ON THE SHORELINE SYSTEMS OF THE HETEROLITHIC UNIT FROM THE TRIASSIC TABULAR COVER OF THE IBERIAN MESETA

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This study is based on field outcrop and core observations, and borehole data from nine behind outcrop wells of the Heterolithic Unit from the Triassic Tabular Cover of the Iberian Meseta (Central Spain). The Heterolithic Unit consists predominantly of 33 m-thick, with Gamma Ray signal between 150 to 100 API mixed sandstones and mudstones deposits overlying to a 20 m-thick clean fluvial sandstones unit (with a characteristic 50 API GR signal). The Heterolithic Unit is topped by the Triassic evaporites.

The Heterolithic Unit is formed by two sequences separated by an erosional surface: (1) a dominantly heterolithic lower subunit (sequence 1) is truncated at the top by a 2 m deep incised channel capped by a mud clast lag and (2) a sand-dominated upper subunit containing coal (sequence 2). The sequence 1 is represented by a transgressive shoreline system passing upward from a (1) succession dominated by bi-directional, ebb-flow dominated cross-bedded sandstones separated by millimetric thick mudstone to siltstone drapes interpreted as tidal bars migrating in a intertidal to subtidal environment towards (2) basal scoured, hummocky-cross bedded fine-grained clean sandstones alternating with fairweather wave-rippled heterolithic beds interpreted as a storm-wave-dominated, tide-influenced open-coast shoreface.

The sequence 2 is represented by a transgressive to regressive river-to tide-dominated delta plain system passing upward from a (1) succession dominated by lateral accretion units interpreted as point bars of distributary meandering channels and coal beds deposited into interdistributary bays towards (2) superposition of several sigmoidal cross-stratified sandstones sets with gradual increase in the foreset dip (including parabolic contorted folds) and also separated by millimetric thick mud drapes, reactivation surfaces, bidirectional ripple and flaser laminations at the toeset interpreted as ebb-flow dominated by tidal bundles deposited into a tide-to wave-influenced distributary mouth bar.

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A FAST REFILL OF THE MEDITERRANEAN AFTER THE MESSINIAN SALINITY CRISIS? LOOKING FOR INDEPENDENT EVIDENCE

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One of the main competing scenarios proposed for the termination of the Messinian salinity crisis consists of a geologically-rapid refill of the Mediterranean after a km-scale drawdown of the Mediterranean Sea level. The main evidence supporting this Zanclean Flood scenario is a nearly 400 km long and several hundred meters deep erosion channel across the Strait of Gibraltar. This erosion channel extends from the Gulf of Cadiz to the Algerian Basin and implies the excavation of ca. 1000 km^3 of Miocene sediment and older bedrock. However, additional evidence supporting this catastrophic flood hypothesis is missing, other than the fast transition from MSC deposits to open-marine facies. Here we test two consequences that an outburst flood of the Mediterranean should imply: First, an excavated channel similar to the one across the Gibraltar Strait should be present in the old sill separating the east and west Mediterranean domains (none has been yet reported). A second smoking gun would be finding the present emplacement of the materials eroded during the Zanclean flood (but quantitative predictions of where to look for them are still missing).

In a first attempt to predict the distribution of those flood deposits, we show results from a 2D numerical model of water flow to simulate the transport of material eroded from the Strait of Gibraltar. We estimate the areas of sediment deposition in the Mediterranean Sea depending on the grain size. Suspended load is deposited in areas sheltered from the jet of incoming water by the local topography and areas where water currents abruptly decrease due to a sudden increase in water depth. Bed-load sediment, in contrast, follows water streamlines and deposits are much more localized than in the case of suspended-load. We compare the results with seismic profiles that may exhibit flood-related deposits in the eastern Alboran Sea.

Furthermore, we make use of a preliminary interpretation of multichannel data in the western Ionian Basin to identify a chaotic body of up to 760 m in thickness and 2400 km^3 in volume. The location of these deposits next to the Cassibile theatre-shaped canyon (SE Sicily margin) suggest that this may have been excavated by a large flow event in the geological past, a hypothesis that we discuss by comparing to other well-known, subaerial megaflooding scenarios.

THE CELTIC SEA: A LARGE MARINE DUNE FIELD WITH SPECIFIC MORPHOLOGIES AT THE LIMIT OF THE CONTINENTAL SLOPE

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The most recent bathymetric surveys conducted by the Shom on the west of Brittany, at depths from 70 to 200 m, allow to delimit a very large dune field, which, had been until now had only been observed by a few old profiles. During the five last years, more than 6,765 dunes were identified with Multibeam Echo Sounder (MES) data. This new bathymetric data show that all the French part of the Celtic Sea is covered by dunes, namely a surface of 31,000 km^2. These are associated with great sandbanks which are not higher but which had been described since more than fifty years. Before the MES, the bathymetric systems did not have the sufficient accuracy for the accurate mapping of dunes at these depths of 100 to 200 meters. As an example of this poor knowledge of the dunes of this region, the Portsall dunes field, composed by more than 300 dunes associated with a sandbank, which is only at 40 kilometers to the French coast, has only been discovered in 2012. 7.7 % of these dunes are higher than 10 meters and some of these highest dunes are barchans. All the dunes observed on the Shom's bathymetric surveys are included in one GIS dedicated to sandbanks and dunes of the French continental shelf. At present more than fifteen thousand dunes are in this GIS, and some thousands of dunes awaiting their integration in this GIS. Most of these dunes are transvers but this work has also highlighted the existence of barchans, of trochoidal dunes, which are similar to those described by Van Landeghem (2009), and upon the limit of the continental shelf and the slope, of dunes until now not described, with specific morphologies. The main direction of the transit is to the south west, and most of the dunes are transverse but we observe locally a variation in the orientation of the dunes and of their morphologies characterizing the complexity of this environment. After describing the Celtic Sea dune fields, and their sedimentary and hydrodynamic environment we describe the different shape of dunes of the limit of the continental slope. Some environments show homogeneous shape of dunes, but frequently dunes of different shapes appear in the same environment. These relations between shape and physical parameters are studied to to present the relation between the environment and the physical characteristics of dunes.

SALT TECTONICS ON THE EASTERN SARDINIAN MARGIN (WESTERN TYRRHENIAN SEA): A PROXY TO REVEAL RECENT POST-RIFT CRUSTAL TECTONICS

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The Western Tyrrhenian Basin is a fascinating basin in terms of interactions between crustal tectonics, salt tectonics and sedimentation. The METYSS (Messinian Event in the Tyrrhenian from Seismic Study) project is based on 2100 km of HR seismic data acquired along the Eastern Sardinian margin. The main aim is to study the Messinian Salinity Crisis (MSC), but we also investigate the thinning processes of the continental crust and the timing of crustal vertical motions across the Western Tyrrhenian Basin. Our first results allowed to map the MSC seismic markers and to better constrain the timing of the rifting, which ended before the MSC across the upper and middle parts of the margin. We also evidenced that crustal activity persisted long after the end of rifting. In this study we investigate the Cornaglia Terrace, where the Mobile Unit (MU, mobile Messinian salt), accumulated during the MSC, acts as a *décollement*. Our goal is to ascertain whether or not crustal tectonics existed after the pre-MSC rift. This is a challenge where the MU is thick, because potential basement deformations could be first accommodated by the MU and therefore would not find any expression in the supra-salt layers (Upper Unit, UU and Plio-Quaternary, PQ). However, our investigations clearly reveal interactions between crustal and salt tectonics. We thus evidence gravity gliding of the salt and its brittle sedimentary cover along basement slopes generated by the post-MSC tilting of some basement blocks bounded by crustal normal faults, formerly due to the rifting. Another intriguing structure corresponds to a wedge-shaped of MU located in a narrow N-S half graben bounded to the west by a major, east-verging, crustal normal fault. Below the MU, the sediments thicken toward the fault. The top of the MU is sub-horizontal and the supra-salt layers are sub-horizontal. At a first glance this geometry would suggest that the pre-salt unit and the MU are syn-tectonic and that nothing happened after Messinian times. However, some subtle evidence of deformations in the UU and PQ imply that some crustal tectonics activity persisted existed after the end of the rifting. To understand why the salt unit is wedge-shaped, we considered several scenarii that we tested with physical modelling. We demonstrate that this structure is related to the post-rift activity of the major crustal normal fault, whose vertical motion has been cushioned by lateral flow of an initially tabular salt layer, which thinned upslope and inflated downslope, keeping the overlying sediments remained sub-horizontal. Such interactions between thin-skinned and thick-skinned tectonics highlight how the analysis of the salt tectonics is a powerful tool to reveal recent deep crustal tectonics in the Western Mediterranean Basin.The analysis of subtle clues in the supra-salt layers and the comparison between natural data and results from experimental modelling have provided crucial information on interactions between thin-skinned and thick-skinned tectonics in the Western Tyrrhenian Basin. It then shows how the analysis of the salt tectonics is a powerful tool to evidence deep crustal vertical motions that would otherwise be too subtle to observe.

GRAVITY-DRIVEN SALT TECTONICS ABOVE A RISING BASEMENT PLATEAU OFFSHORE ALGERIA

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Seismic data (survey "MARADJA 1", 2003) offshore the Algerian coast have imaged an unexpected deformation pattern of the Messinian salt (Mobile Unit; MU) and its sedimentary overburden (Messinian Upper Unit and Plio-Quaternary) above an actively rising plateau in the subsalt basement. From a geodynamic point of view, the region is undergoing crustal convergence, as attested by the Boumerdes earthquake (2003, magnitude 6.8). The rise of this plateau, forming a 3D promontory restricted to the area offshore Algiers, is associated with that geodynamic setting. The seismic profiles show several subsalt thrusts (Domzig et al. 2006). The data provided additional information on the deformation of the Messinian mobile evaporitic unit and its Plio-Quaternary overburden. Margin-perpendicular profiles show mostly compressional features (anticlines and synclines) that had little activity during Messinian times, then grew more during PlioQuaternary times. A few normal faults are also present, but are not accompanied by salt rise. By contrast, margin-parallel profiles clearly show that extensional, reactive salt diapiric ridges (symptomatic with their triangular shape in cross section) formed early, as early as the time of deposition of the Messinian Upper Unit, as recorded by fan-shaped strata. These ridges have recorded E-W, thin-skinned gravity gliding above the Messinian salt, as a response to the rise of the basement plateau. We tested this hypothesis using two analogue models, one where we assumed that the rise of the plateau started after Messinian times (initially tabular salt across the entire region), the second model assumed that the plateau had already risen partially as the Messininan Mobile Unit was deposited (salt initially thinner above the plateau than in the adjacent regions). In both experiments, the rise of the plateau generated preferential E-W extension above the salt, combined with N-S shortening. Extension was caused by gravity gliding of the salt from above the rising basement toward the deeper adjacent basins. So far, the deformation pattern of the salt and overburden on the plateau did not allow us to use it as a clear indicator of whether the plateau's rise started before or during Messinian times.

THE WESTERN TYRRHENIAN SEA REVISITED: A NEW STATUS FOR THE EASTERN SARDINIAN MARGIN DURING THE MESSINIAN SALINITY CRISIS

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In the last fifty years, the Messinian Salinity Crisis (MSC) has been widely investigated through the Mediterranean Sea, but a major basin remains fewly explored in terms of MSC thematic: the Western Tyrrhenian Basin. The rifting of this back-arc basin is considered to occur between the Middle-Miocene and the Early-Pliocene, thus including the MSC, giving a unic opportunity to study this crisis in a context of active geodynamics. However, the MSC seismic markers in the Western part of the Tyrrhenian Sea have only been investigated in the early eighties and the MSC event in the Western Tyrrhenian Basin remains poorly studied and unclear. In this study, we revisit the MSC in the Western Tyrrhenian Basin, i.e. along the Eastern Sardinian margin. We present results from the interpretation of a 2400 km long HR seismic-reflection dataset, acquired along the margin during the "METYSS" research cruises in 2009 and 2011. The maps of the MSC seismic markers reveal that the Eastern Sardinian margin was already dissected in structurals highs and lows during the MSC. We also demonstrate that the MSC markers constitute powerfull timemarkers to refine the age of the rifting, which ended earlier than expected in the East-Sardinian Basin and the Cornaglia Terrace. These results allow us to propose a new status for the Eastern Sardinian margin during the MSC and to discuss the depths at which the seismic MSC units (particularly the "Upper Unit") were deposited across the margin.

SEDIMENTARY RECORDS OF PALEOEARTHQUAKES IN THE MESOZOIC–CENOZOIC TERRIGENOUS SEQUENCES OF THE NORTHERN CAUCASUS

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Analysis of the distribution of traces of paleoearthquakes in the Mesozoic–Cenozoic terrigenous sequences of the Northern Caucasus revealed that its Alpine epoch evolution was characterized by high seismic activity. Relatively calm periods were replaced by the reactivation of seismicity often owing to variations in the tectonic setting of the region. This is suggested by signs of the increase of seismic activity confined to the upper part of large sedimentary cycles of the first order: increase in the number of paleoearthquakes preceded and accompanied the transition to the next stage of intensification of the paleobasin bed subsidence. Comparison of seismites in the different-age terrigenous sequences shows that their manifestation pattern depends appreciably on the composition and lithification degree of sediments. Most favorable for the fixation of traces of earthquakes therein are the sandy–clayey sediments, in particular, Middle Miocene sediments in the eastern Caucasus. Paleoearthquakes promoted the formation of numerous and diverse (in morphology and size) secondary rocks corresponding to a certain seismic event in the sandy–clayey sequence. They make up a single seismic complex including the following elements: seismic event horizons (SEH) represented by intensely deformed and destructurized rocks; associated clastic dikes, sills, and other injection bodies; rocks underlying the SEH and usually retaining the primary bedded structure. These rocks include traces of the seismic impact (sandy beds with signs of liquefaction, abrupt swelling and thinning, horizontal overthrusting, jointing, and so on).

The pattern of seismites changes toward the west – the Dagestan-type seismites are already missing in the central areas of Chechnya due to the attenuation of seismic activity. Here, seismic events are suggested by the subvertical pyramidal concretions and carbonate dikes, which were produced by the migration of diagenetic interstitial waters saturated with Fe–Mg–Ca bicarbonates along seismogenic fractures. The general trend of east-to-west attenuation of the Middle Miocene seismic activity is recorded quite confidently in the eastern sector of the northern Caucasus. Therefore, we can assume that the modern pattern of seismic activity in this region already existed here in Miocene.

In the relatively monotonous Oligocene (Maikopian) clayey sediments traces of earthquakes are fixed less clearly than in the Middle Miocene sequence. In most cases, they are expressed as bed intervals with abundant seismogenic fractures. The development of fractures in the near-surface beds stipulated the appearance of cellular structure in sediments. In the deeper and more lithified sediments, fractures were either chaotically distributed or developed along the subvertical direction. Owing to the abundance of seismogenic jointing, the Maikopian sediments acquired the fissure-type reservoir properties.

The kilometer-scale Lower–Middle Jurassic sedimentary sequence incorporates diverse signs of postsedimentary distortions of the primary sedimentary structure of sediments related to the seismic activity. Often, traces of paleoearthquakes are confined to boundary rocks of different formations related to variations in the tectonic setting and paleogeographic environment in the paleobasin. We deciphered numerous earthquake-induced downslope dislocations of fragments (up to 10–15 km across) of sedimentary sequences in the basin.

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3D MORPHOLOGY AND TIMING OF A FOSSIL POCKMARK: EXAMPLE IN THE SE BASIN OF FRANCE

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Many studies have attempted to establish a relationship between fluid seeps and their supposed source in sedimentary basins. The architecture of the migration network, however, has long remained uncertain and neither the source of the fluids, nor the initiation processes, nor their mode of expulsion were clearly established.

The use, in academic world from the 2000s, of 3D seismic data and high-resolution seabed imaging, has led to significant breakthroughs by first defining a geophysical signature of fluid pipes (150-200 m in diameter) thanks to the gas they contain or to carbonate precipitation driven by biochemical interaction with host sediments. These pipes, when they reach the seabed, generally form a fluid seep structure (pockmarks or mud volcanoes).

However, data acquired over modern seafloors do not have a resolution sufficient to image the inner structure of a fluid seep structure, particularly in the shallow subsurface. In the South-East basin of France (Drôme), we identified a fossil cold seep structure made of fossil-rich carbonate lenses that we interpreted as a 600 m wide pockmark. Based on 23 stratigraphic logs within the structure we were able to correlate all fluid seep events in the area. It clearly shows that only a few is emitting fluids at the same time. It means that the underlying focused fluid flow in pipes is migrating laterally over time. It also means that pipes are concentrated in a cone structure whose the base represent the source of the fluids as shown in modern basins, such as in the Voring basin or in the Gulf of Lion.

In conclusion, even if fluid migration is triggered by allochtonous processes such as fluid overpressure at the top of a reservoir, sea-level variations or tectonic stresses, the migration itself is more controlled by fluid-rock interactions. Further investigations, sandbox and numeric modelling, will be the next steps to better understand physical properties during focused fluid migration in the shallow and unconsolidated interval of sedimentary basins.

SEAFLOOR GIANT POLYGONS ASSOCIATED WITH UNDERLYING POLYGONAL FAULTS IN THE CARIBBEAN SEA, WEST OF GRENADA BASIN

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The initial sediment lithification reactions start with complex interactions involving all components of the sedimentary material (minerals, surface water, decomposing organic matter and living organisms). This is the eogenesis domain (0 to 2000 m below seafloor), covering a burial interval ranging from the interface with the biosphere down to depths where physical compaction processes become predominant. Compared to studies performed on sedimentation (and sedimentary dynamics) and on deep diagenesis (mesogenesis), there is a true lack of data concerning diagenetic processes occurring during eogenesis, in particular concerning siliciclastic diagenesis. However, shallow sediments within the eogenesis domain undergo intense deformation and fracturing. In clay-rich sediments the created faults are organized in polygons due to the volumetric contraction leading to a volume loss during burial. The polygonal fault systems (PFS) have been identified in many basins worldwide, such as in the China Sea, in the Australian Eromanga Basin, in the Lower Congo Basin, in the Danish Central Trough, in the Canadian Atlantic margin and in the Irish Sea. These areas are all located in petroleum provinces, either onshore or at water depths ranging from 200 to 1500 m.

During the Garanti Cruise in May-June 2017, giant polygons have been identified on the slope of the Caribbean sea, west of Grenada Basin, between 1800 and 2500 m water depth. On seismic profiles the polygonal faults are characterized by an intense dimming of reflections on both edges of the fault planes suggesting that fluids are currently migrating upward. They affect a 700 to 900 m thick interval and they can locally reach the modern seafloor where they form polygons visible on multibeam data. On chirp profiles, the polygons have very steep flanks, defining rectilinear depressions (or furrows) that are 40 m deep compared to the regional slope.

Various mechanisms have been referenced in the literature as responsible for polygonal fault initiation and propagation, such as diagenetic transformations or reactivation by sediment loading for instance. Four hypotheses are actually proposed to explain the formation of these polygonal faults: i) syneresis related to colloidal properties of such fine-grained sediments, ii) density inversions and associated hydrofracturing, iii) smectite-rich clays causing residual friction at low burial depth and iv) grain dissolution in uncemented media inducing a decrease in horizontal stress that leads to shear failure and shear strain localization.

In the Grenada basin it seems that the volumetrical contraction starts very early after deposition suggesting that the smectite-rich clays play a key role in the formation of polygons. This is compatible with the volcano-clastic context in the area where clays may come from the in-situ alteration of volcanic material.

CARBONATE SLOPES AND ASSOCIATED PLATFORM-MARGIN FACIES, PENNSYLVANIAN–PERMIAN PLATFORMS OF THE LOEI-PHETCHABUN FOLDBELT, NE THAILAND

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Pennyslvanian–Middle Permian carbonate platforms of NE Thailand developed on faulted and thinned continental crust along the (now) western margin of Indochina. Although the facies associations preserved in outcrop in the Loei-Phetchabun Foldbelt (LPF) mainly represent platform-top environments, systematic mapping and facies characterisation, has identified important platform margin and slope facies associations. Identification of slope facies has led to recovery of conodont taxa that, along with other fossil groups, have provided improved biostratigraphic control and especially correlation across faults. Slope facies including prominent carbonate breccias, allochthonous blocks and crinoid-rich grainstones provide evidence for changes in platform morphology and relative sea-level fluctuations. In the northern LPF we recognise mixed carbonate-siliciclastic ramps (Bashkirian–Moscovian) overlain by rimmed platform phases (~late Moscovian–Cisuralian) that include major influxes of siliciclastic sediment. Throughout platform development, platform-margin facies are diverse, including a range of mounds and patch reefs composed of distinctive biotic assemblages. Microbial components in these boundstones are widespread and were important in reefal construction than previously recognized. Microbialite, sponge-microbialite and large phylloid algal-microbial mounds occupied platform margin positions (off-platform/outer ramp). Skeletal–intraclastic facies with diverse encrusting organisms, or displaying clotted or stromatolitic fabrics, suggest binding and stabilization of sandy shoals. Characterisation of margins and slopes within overall reconstruction of the stratal architecture of these platforms is timely given the acquisition of new 3D geophysical data over the gas fields which will ultimately improve interpretation of subsurface architecture.

EVOLUTION OF THE NEOPROTEROZOIC MARWAR SUPERGROUP, WESTERN INDIA: INSIGHTS FROM CHEMOSTRATIGRAPHY AND SEDIMENT PROVENANCE STUDY

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The Marwar Supergroup of the western India is the largest Late Neoproterozoic sedimentary sequence of India. Deposited in an intracratonic basin with the ~750 Ma Malani Igneous Complex as its basement, the Supergroup consists of unmetamorphosed and undeformed fluvial siliciclastics, marine carbonates, and minor volcaniclastics. To better understand the evolution of the Proterozoic oceans and to decipher the post Rodinian tectono-climatic conditions prevailed in the Indian shield, we have carried out stable carbon and oxygen isotopic studies of the marine carbonates in the basin, provided age constraints using Sr isotopestratigraphy, and determined the provenance of the siliciclastic sediments using Nd isotopes.

Our attempt to constrain the age of deposition of the middle Marwar Bilara carbonates using Sr isotope stratigraphy provides a lowest $^{87}Sr/^{86}Sr = 0.7081$, which suggests an Ediacaran age of ~570 Ma for the formation. The mode of $\delta^{13}C$ of the Bilara carbonates is 0 ± 2 ‰ and $\delta^{18}O$ varies from -10 to +4 ‰, the former consistent with late Ediacaran carbonate deposits worldwide. There are a few $\delta^{13}C$ negative excursions which we interpret as variations associated with changes in facies. The ~570 Ma age and $\delta^{13}C$ value of ~0 ‰ in the Bilara Limestone suggest that the carbonates were deposited subsequent to the Snowball Earth events.

The siliciclastic sediments of the Marwar possess very low εNd (-22.4 to -9.1) and the TDM in the range of 2.8 to 1.2 Ga, with a mode at 2.0 Ga; which clearly suggest derivation of these sediments from early Precambrian crustal rocks and younger granites. Mixing models reveal that most of the sediments were sourced from the Delhi Supergroup, Banded Gneissic Complex-II and Erinpura Granites; all located within the Delhi Fold Belts at the eastern boundary of the Marwar basin.

SEQUENCE AND FACIES ARCHITECTURE OF THE LOWER CAMBRIAN ARABA FORMATION, TABA-NAQAB ROAD, SOUTHEAST SINAI, EGYPT

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The Lower Cambrian siliciclastic dominated Araba Formation crops out at the Taba-Naqab Road, southeast Sinai, Egypt resting nonconformably above the Precambrian Basement Complex. It was deposited in an intracratonic basin along the northern margin of Gondwana forming with other deposits in the neighboring countries the most extensive first-cycle compositionally mature quartz-rich detrital deposits ever deposited on continental crust. Facies and sequence stratigraphic interpretations of the Araba Formation provide significant information on sedimentation and environmental changes in North Gondwana during Early Paleozoic. The results of this study will be correlated with other Cambrian strata in Egypt and surrounding countries to elucidate the possible local and regional controls on sedimentation. Sedimentary facies were identified and interpreted representing the deposits of 1) braided fluvial dominantly coarsegrained sandstones (A), 2) stream/sheet flood mixed conglomerate-sandstones (B), 3) high sinuosity fluvial deposits (C), 4) floodplain deposits (D), 5) Intertidal flat deposits (E), 6) subtidal/shoreface sandstones (F), 7) shoreface-offshore deposits (G), 8) paleosol (H), and 9) shallow marine sandstones (I). The vertical stratigraphic changes indicate an overall retrogradation trend. The sequence stratigraphic framework includes three sequences. The basal sequence (SQ1) consists of braided fluvial deposits nonconformably overlying Precambrian rocks and the upper boundary is delineated at the contact with the overlying gravel-rich stream/ sheet flood deposits. This boundary is defined by the abrupt change in sediment composition and grain size possibly attributed to a tectonically induced shift in the source area. The second sequence consists of upward deepening transgressive deposits B→C→D→E→F→G truncated by the basal surface of forced regression that is sharply overlain by upper shoreface sandstones (F) which in turn is overlain by paleosol (H) suggesting forced regression. The third sequence is incomplete one consisting of upward deepening intertidal flat sandstones (E) sharply and erosively overlain by shallow marine coarse-grained sandstones (I). The upper sequence boundary was not recognized. The upward progressive disappearance of fluvial deposits and the increase of marine and marine influenced deposits designated a general retrogradation architecture that is consistent with the transgressive trend for the North Gondwana during earliest Paleozoic. Eustatic sea level variation with less significant local tectonic activity were the plausible controls on sedimentation and stratigraphic architecture of the Araba Formation.

SEDIMENTARY FACIES AND STRATIGRAPHIC EVOLUTION OF THE LOWER JURASSIC MASHABBA FORMATION, GEBEL AL-MAGHARA, NORTH SINAI, EGYPT

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This study focuses on the controlling factors on the sedimentation and stratigraphic evolution of the Lower Jurassic Mashabba Formation that is cropping out at the core of the NE-SW oriented doubly plunging anticline Al-Maghara, North Sinai, Egypt. The study provides also a criterion in addition to tidal signals to define the fluvio-marine transition. The sediments of the Mashabba Formation were deposited within a rift basin forming with the opening of the Neotethys during Late Paleozoic-Early Mesozoic times. A laterally extensive calcareous sandstone bed divides the ~ 90 m thick Mashabba Formation into two members of different lateral extension and depositional settings; a sand-dominated lower member and a mixed carbonate-siliciclastic upper member. The sedimentary facies of the lower member are laterally extensive and are composed of shallow marine offshore-shoreface, coastal/delta plain and fluvial, estuarine and incised valley fill deposits. In contrast, the upper member consists of laterally confined fossiliferous limestones of lagoonal and shallow-marine origin alternating with upward-coarsening, mostly burrowed sandstones of marginal marine deltaic and/or tidal flat origin. Facies stacking enabled the identification of seven transgressive-regressive cycles; three in the lower member and four in the upper member. The turnaround from upward-deepening into upward-shallowing facies delineates the transition from transgressive to regressive trend. Tectonics and climate were the major controls on sedimentation and stratigraphic evolution of the Mashabba Formation. Facies stacking in an unpredictable manner and the limited lateral distribution of certain sedimentary facies particularly in the upper Mashabba Member and the absence of major subaerial unconformities suggest that tectonic pulses controlled the rate and trends of accommodation space, the shoreline morphology and the siliciclastic sediment entry point. The up-section change from relatively thick fluvial deposits containing abundant plant remains and tree trunks in the lower Mashabba Member into the carbonate-rich upper Mashabba Member reflects shift in climate from humid to relatively arid. An upward change in architectural element within fluvial deposits from a downstream accreted element (DA) to laterally accreted macroforms (LA) can be used to delineate the fluvio-marine transition and hence the turnaround from low to high accommodation systems tracts.

FROM SHELF TO BASIN, ANATOMY OF A GLACIATION RECORD (UPPER ORDOVICIAN, MOROCCO; ANR SEQSTRAT-ICE PROJECT 2013-2017)

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We investigated the Hirnantian glaciation record based on sedimentology, 3D architecture, palynology, carbon isotopes and provenance study. Four settings of the Moroccan Gondwana platform are documented: proximal and distal shelves, shelf canyons and "deep-water" fans; the three former experiencing subglacial erosion during the glaciation acme. Contrasted successions at the 100 km scale allow inspection of sediment partitioning through the glacial event.

The proximal shelf shows storm-dominated highstand wedges eroded by poorly differentiated glacial surfaces or deeply truncated by sand-filled tunnel valleys. The main part of the record however consists of a single glacial retreat succession comprised of a glaciomarine wedge and an overlying forced regressive delta, both coeval with the final glacio-isostatic rebound (cf. presentation by P. Dietrich et al.).

In the distal shelf, glacio-eustatic lowstand wedges bounded by flooding surfaces recorded the glaciation onset occurring more inland. Later, the glacial record s.s. is accommodated in shallow glacial incisions floored by glaciofluvials. Prior to the glacial maximum, glaciomarine and tidal deposits constitute fingerprints of subordinate retreat phases. The glacial maximum-ice-sheet front at > 200 km beyond the study area-is restricted to a single glacial surface and an ensuing glacio-isostatically forced progradation; the latter being interrupted by an ultimate glacial advance (an ice lobe?), which built a fold-and-thrust belt deforming outwash sands. Shelf canyons, < 500 m deep, 2-10 km wide, were cut by retrogressive erosion in preglaciation deposits. Their re-incision likely occurred during the early lowstands, as they did also before, and after, the Hirnantian. In-canyon active sedimentation and accumulation characterize periods when, and places where a grounding line occupied the canyon. Glaciomarine deposits are tied to rapid ice retreat phases. During ice minima, tidally-influenced sands were deposited at canyon heads whilst, downslope, starved systems developed.

The deep-water turbiditic succession (> 350 m) includes a single glaciomarine interval and two coarser-grained sandsheets (50-75 m) representing oversupplied conditions. A ^{13}C isotopic signal allows its correlation with basins of intermediate latitudes. Whether the turbidites were issuing from a canyon or from a shelf apron is unknown but most of the succession relates to the glaciation acme. The poor development of glaciomarine deposits suggests a buffer-in-canyon grounding-line fans or subaerial sandar, respectively between the ice front and the deep-water depocenter. Detrital zircon geochronology suggests a significant contribution of reworked preglacial deposits remobilized at lowstand conditions. Actual glaciogenics tied to maximum glacial advances represent less than 50% of the succession. Those are mature sandstones remobilized via subglacial erosion from the inner glaciated platform.

None of the four settings offers a comprehensive glacial record, yet separately, each fairly documents one particular stage within the glaciation development (e.g., glacial advances preceding the glaciation acme, early glacial retreat). Waiting for a refined Hirnantian chitinozoan biozonation, high-resolution correlations from one setting to the other essentially rely on sequence stratigraphic inferences. A provenance study is currently in progress to corroborate the shelf-scale correlation framework. Correlations with glacial cycles preserved over the inner platform (Mauritania, Algeria, Libya) remain controversial.

GEOCHEMICAL COMPOSITION OF THE MIOCENE SEDIMENTS IN NEYRIZ REGION, IRAN: IMPLICATION FOR PROVENANCE

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Elemental geochemistry of the Miocene sediments in Neyriz region were carried out to determine their provenance, tectonic setting and paleoclimate conditions in the proximal part of Zagros Basin. The Miocene sediments are limited to the Zagros Main Fault at the northeast and the Neyriz ophiolite zone at the southwest in the Neyriz region. They contain about 400 m red and green sandstone, conglomerate which are bounded unconformably between the Jahrum Formation and Bakhtiari conglomerate. Petrography of the rock fragments and the bulk chemical composition of samples display that their provenance is multiple and the sediments were derived from Sanandaj-Sirjan Zone (Cretaceous limestone-metamorphic rocks-Eocene volcanic) and Zagros Zone (ophiolite sequence radiolarites-Eocene limestone). Based on geochemical data tectonic setting of Neyriz Miocene sediments is continental island arc and active continental margin. The averages of ICV (to determine the maturity source), and SiO_2 versus Al_2O_3 + K_2O + Na_2O diagram for these sediments show a poor weathering and dry climatic condition during their deposition which is supported by the high percentage of calcareous cement and frequency of the rock fragments. The results of this study suggest a sedimentlogical framework for the proximal part of Zagros Basin.

THE STABLE ISOTOPIC COMPOSITION OF THE FRESHWATER MICROBIALITES OF THE LATE TRIASSIC MALERI FORMATION, INDIA

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The freshwater microbial carbonates in the rock record provide valuable insight into the physical and biotic conditions of the past. This work discusses the implications of the stable isotopic composition of some thin and impersistent freshwater carbonates preserved within a Late Triassic fluvial deposit known as the Maleri Formation.

This formation is a part of the syn-rift sedimentary succession of the Pranhita-Godavari continental rift basin, India. Very thin sheets of laminated marls and impure limestones as well as innumerable lenticular to sheet-like, decimetre thick bodies of cross-bedded carbonate grainstones occur at all stratigraphic levels within these fluvial mudstones and sandstones. The microscopic features of the carbonates suggest that biological processes played an active role in carbonate precipitation.

The average $\delta^{13}C$ and $\delta^{18}O$ values for the Maleri carbonate samples (grainstones and marls/impure limestones) are- 7.30‰ ± 0.15‰ and -5.16‰ ± 0.21‰ respectively. The grainstone samples show a higher spread of oxygen isotopic values compared to that of the marls/limestones. Whereas, a comparatively higher spread of carbon isotopic values has been noted for the samples of marls/limestones. Again, the marl/limestone samples are slightly enriched in $\delta^{18}O$ compared to the grainstones.

Distinctly negative $\delta^{13}C$ and $\delta^{18}O$ values of the all the samples indicate that the carbonates were precipitated in freshwater environment. Further, these compositions are very similar to those reported from modern freshwater tufa carbonates.

In this case the carbon and oxygen isotopic values are typically uncorrelated. The poor correlation suggests insignificant evaporation and degassing. However, it is inapt to assume complete absence of evaporation and degassing as these carbonates were formed in small and ephemeral water bodies within a fluvial environment. The photosynthesis and respiration of microbial community can significantly affect the $\delta^{13}C$ composition. Therefore, as in this case microbes were present in large number in small water bodies, their biological activities were likely to have masked the signatures of abiotic processes.

According to the observed correlation between the $\delta^{18}O$ of local precipitation and microbial carbonate, the Maleri carbonates were formed in water with temperature varying between 10 and 15°C. Again, signatures of microbial activity, presence of stems of higher plants, organic debris, aquatic invertebrates and vertebrates, also suggests an ambient water temperature.

The $\delta^{13}C$ composition of the freshwater carbonate is mainly dependent on the composition of local DIC pool. Both the autotrophic and heterotrophic metabolisms can influence the composition of local DIC. However, the direction of deviation affecting the isotopic composition of DIC depends on whether autotrophic or heterotrophic processes are dominant.

The isotopic composition of the Proterozoic Limestones at the source area would have produced a DIC composition of c. -13‰ for Maleri. However, the composition of the Maleri carbonates suggests a DIC composition of ~-18‰, which is ~5‰ depleted. As both degassing and photosynthesis by cyanobacteria leads to enrichment of the $\delta^{13}C$ of the carbonate, the observed depletion suggests that these carbonates mostly record the signature of heterotropic activity of the microbial community.

CRYPTIC SIGNALS OF THE LATE TRIASSIC FRESHWATER CARBONATE DEPOSITIONAL ENVIRONMENTS IN A CONTINENTAL RIFT BASIN

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The freshwater carbonates preserved in rock record provide valuable information on physical and biotic environments of the past. This work describes the macroscopic and microscopic features of some thin and impersistent carbonates preserved within a thick siliciclastic fluvial deposit. These observations help in reconstructing the carbonate depositional environments in a continental rift basin.

The Late Triassic Maleri Formation (300-500 m thick), India, is a part of the syn-rift sedimentary succession. Thick units of red, laminated siltstones, a few (5 to 20 m thick) sheet sandstone bodies and thinner bodies of massive mudstones are the main lithological components. Unidirectional-unimodal paleotransport pattern, numerous non-marine vertebrate and invertebrate fossils and complete absence of marine fossils suggest that it is a fluvial deposit. The siltstones (silt to very-fine sand-sized pedogenic mud aggregates) and the fine-grained sandstones show sedimentary features indicative of emplacement from unconfined sheet-flows. The pedogenic features preserved in the massive red mudstones indicate deposition of fines (clastic) in swampy area. Pedogenic carbonate concretions are, however, typically absent. Yet, very thin sheets of laminated marls and impure limestones as well as innumerable lenticular to sheet-like, decimetre thick bodies of cross-bedded carbonate grainstones occur at all stratigraphic levels. The microscopic features suggest that biological processes played an active role in carbonate precipitation.

The marls are virtually free of siliciclastic detritus and contain articulated shells of freshwater bivalves and plant debris. Lamination is crude and made up of alternating dark and light micritic (organic matter-rich) and microsparitic layers. The calcite crystals are flaky and contain tubular pores suggesting activity of microbes. Again, the presence of numerous lamina-bound desiccation cracks, larger root canals and burrows indicate repeated subaerial modification of carbonate mud in a palustrine environment.

The impure limestones are crudely layered deposits of coated phytoclasts and siliciclastic grains alternating with siliciclastic mud. The layers are broken and deformed to varying degree. The coating is made up of tufts of radiating curved filamentous calcite crystals growing on a substrate of ironstained micrite. The adjacent tufts are similar in size and are arranged side by side forming palisades with sharp and planar outer margin. Silt-sized quartz grains are trapped in between the tufts. These coatings resemble modern microbial mats produced by freshwater cyanobacteria (e.g., *Schizothrix*) or those produced by bryophytes around phytoclasts and other detritus in modern tufa.

Massive micritic pelloids, oncoids and the grains made up of a mosaic of polycrystals are common in the framework of the grainstones. Their internal fabric indicate that these grains are the fragments of the marls and impure limestones described above.

These freshwater carbonates of the Maleri Formation, therefore, indicate the presence of palustrine and tufa-like environments in isolated pools and lakes that coexisted with the fluvial system of the rift basin. The dissolution of Proterozoic limestones at the source possibly fed these carbonate precipitating environments with bicarbonate-rich water. The periodic erosion of concomitantly precipitated carbonates by fluvial flows produced the detrital grains found in the Maleri grainstones.

MARINE TO CONTINENTAL EVAPORITIC UNITS OF THE BETIC CORRIDOR AND THE INITIATION OF THE MESSINIAN SALINITY CRISIS

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During the Tortonian the Betic Cordillera formed an archipelago of islands that emerged gradually within the Betic corridor. This strait was formed by a series of marine sea-ways and interconnected sedimentary basins that allowed the connection between the Mediterranean and the Atlantic. The progressive rise of the Betic range produced the continentalization of the basins located in the internal part of the cordillera and the disconnection of the Atlantic and the Mediterranean through the Betic corridor. The closure of the different gateways produced a restriction in the circulation of the Mediterranean waters that would culminate with the Messinian Salinity Crisis.

The integration of data from the Betic Cordillera allows to distinguish two groups of evaporitic formations generated in this important paleogeographic process: Evaporitic units of late Tortonian-early Messinian age (7.8-6.8 Ma), related to the continentalization of Betic basins located in the internal part of the Cordillera (Granada, Lorca, Campo Coy, Baza, Fortuna, Jumilla, Hellín) and B) units deposited in the marginal Betic basins (Sorbas, Nijar, Bajo Segura and the Balearic Promontory basins), all of them contemporaneous and formed during the middle-late Messinian as a result of an increased restriction of the Mediterranean (5.98-5.33 Ma). A gap of around 1 Ma seems to exist between the formation of these two groups of evaporitic units, although the evaporites deposited in the marginal basins are preceded by sediments that show evidence of restriction prior to the deposition of gypsum. The formation of these preevaporitic sediments (Abad Mb in Nijar and Sorbas basins or Tripoli Mb in Sicily) seems to be coincident with the time of closure of the Betic corridor. In addition, vertebrate faunal fossils identified in Iberia and North Africa shows an Afro-Iberian exchange of fauna prior to the onset of the MSC, indicating already important restriction in the Mediterranean-Atlantic connection at 6.25 Ma.

We use geochemical proxies from boreholes and outcrops to constrain the marine to non marine stages in evaporitic units from different inner Betic basins and we update geochronological data to constrain the time of their continentalization. Finally, we integrate the different evaporitic units in a refined chronostratigraphic frame allowing a review of the paleogeographical evolution of the Betic corridor.

A MEDITERRANEAN REALM AS EARLY AS LOWER TO MIDDLE MIOCENE IN SE FRANCE AND CENTRAL SPAIN RECONSTRUCTED FROM CALCISOLS

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Calcisols are widely distributed in the fossil continental successions. Due to the interactions between leaching and accumulation processes of chemical elements in these soil profiles, classic climofunctions cannot be applied to this type of soil.

Climofunctions dedicated to calcisol have been developed based on geochemical analysis conducted on modern calcisols. They relate the present climate parameters [mean annual precipitation (MAP) and mean annual temperature (MAT)] to indexes built from the major element concentrations in the soil profiles.

Comparisons of the paleoclimatic reconstructions from the paleosol morphologic characteristics and the climofunctions show a good agreement. The climofunctions present the advantage to be applied to truncated paleosols whereas well preserved profiles are needed for the morphologic approach. Thus, the paleoclimatic reconstruction from the paleosol morphology and the major element concentration provides us with several key parameters such as MAP, MAT and MARP (mean annual range of precipitation).

Application of these climofunctions to the SE France and Central Spain lower to middle Miocene continental successions reveals fairly comparable values between the two regions (MAT between 13 to 19°C and MAP ranging from 250-700 mm/yr). Comparison with other paleoclimate reconstructions for the same period in western Europe (mainly Germany, Portugal, northern Spain) indicates similar temperatures, but precipitations that are twofold larger than in the studied area.

Such results raise the question of the setting up of a climatic belt as early as lower Miocene in south eastern France and Central Spain, which had later evolved into the modern Mediterranean climate.

PERVASIVE HYDROTHERMAL DIAGENESIS IN THE PRE-SALT CARBONATE RESERVOIRS OF THE KWANZA BASIN, OFFSHORE ANGOLA

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The Lower Cretaceous Pre-salt carbonates deposited in the Kwanza basin during the early stages of the opening of the South Atlantic Ocean constitute significant targets for oil and gas exploration. These synrift (Barremian) and sag (Aptian) carbonates are predominantly composed of continental deposits, showing variable sedimentary facies and complex diagenetic transformations. In order to improve our understanding of this unusual diagenesis, a detailed integrated study was conducted on a reference well located offshore Angola, in the southwestern part of the Kwanza basin near the Benguela Transfer Fault Zone. This structural feature represents a major segmentation in the West African margin, affected by various episodes of volcanism. Petrography, fluid inclusions, isotope geochemistry ($\delta^{18}O$, $\delta^{13}C$, $^{87}Sr/^{86}Sr$) and U/Pb age data were gathered for samples from the Aptian lacustrine carbonates of the Chela Formation and the underlying heterolithic silty-sandstones of the Cuvo formation, presently occurring at ~5-6 km depth and ~100°C temperature. The Cuvo formation recorded magmatic events showing as intercalated volcanic layers and igneous intrusions.

The studied Pre-Salt reservoirs exhibit multiple generations of cements occurring as matrix-replacive, pore-fill or fracture-vein fill. In the Chela Fm, the main diagenetic phases are extensive dolomitization and silicification, followed by late vein/vug calcite. In the Cuvo Fm, the main transformations are early (matrix) dolomite/calcite, quartz overgrowth, chalcedony/quartz veins, and late calcite veins. Significant dissolution events are also observed in both formations, which contribute to enhance reservoir properties. Fluid inclusions record paleo-temperatures significantly hotter than today, exceeding 150°C and approaching ~200″C, and the ubiquitous presence of highly saline brines (200-300g/l). Combining U/Pb ages measured on a few diagenetic cements with fluid inclusion temperatures documents the existence of a heat pulse relatively early after deposition, and places constraints on the timing of hydrocarbon emplacement. Widespread CO_2 gas inclusions record the presence of CO_2 through most of the post-depositional history, and suggest multiple pulses of CO_2 mixed with variable CH_4. Bulk $\delta^{18}O$-$\delta^{13}C$ of Chela and Cuvo carbonates are compatible with expected values for continental lacustrine deposits, but do not show any distinct trend.

Highly radiogenic bulk $^{87}Sr/^{86}Sr$ values likely reflect primarily Sr derived from Proterozoic basement. $\delta^{18}O$-$\delta^{13}C$ microanalyses of individual cements performed by SIMS document significant variation at thin section scale, which must reflect variation in conditions of formation, however modal values can be derived for each phase. SIMS $\delta^{18}O$ modal values combined with fluid inclusion temperatures indicate that cement-forming waters were 18O-rich brines, primarily of hydrothermal origin. No evidence for any significant influence of marine water was found in the studied Pre-salt deposits.

Overall, the results of our integrated diagenetic study demonstrate that 1) Pre-salt reservoirs were heated to high temperatures (> 150°C) within 15-20 Ma after deposition, 2) diagenetic waters were predominantly highly saline brines of hydrothermal origin, 3) CO_2 was present in the reservoir early on and recorded multiple pulses. We conclude that the Pre-salt reservoirs in the deep offshore domain of the southwestern Kwanza basin have been the locus of pervasive hydrothermal diagenesis in relation with their location near a major Transform Fault Zone.

PETROGRAPHY, SEDIMENTOLOGY AND SOURCE PROVENANCE OF OUTCROPPING BASEMENT OF THE DEMERARA MARGINAL PLATEAU (FRENCH GUIANA-SURINAM): RESULTS FROM DRADEM DREDGES

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At the connection between the Central and the Equatorial Atlantic, the Demerara marginal plateau is a continental margin that resulted from both Jurassic and Cretaceous rifting. The basement of the plateau is unknown, the older rocks recovered in an industrial drillhole being late Jurassic to lower Cretaceous limestones. The northern edge of the plateau is a steep transform margin, where deeper and older basement was expected to outcrop. The DRADEM cruise (2016) dredged this continental slope on seven sites from 4700 to 3500 m depths.

Three dredges recovered magmatic rocks, six dredges recovered sedimentary rocks. All samples were analysed using optical and electronic microscope and X-ray diffraction. Magmatic rocks were also analysed for major elements. Zircons were separated from three sedimentary rocks, in order to date their cristallisation from U/Pb isotopes and their cooling from fission tracks.

In two adjacent dredges, magmatic rocks correspond to fresh basalts and rhyolites belonging to a calc-alcaline, Ti-rich suite. Zircons in rhyolites were dated at 173.4 ± 1.6 Ma. In a third dredge, magmatic rocks are trachy-basalts and basaltic trachy-andesites. These trachy-basalts were altered, eroded, and sedimented in a carbonate platform forming clasts in a bioclastic and lithoclastic rudstone. Large aragonitic shells were dissolved, and the moldic porosity is partially filled by vadose silts, indicating post-sedimentation outcropping above sea-level. The other sites recovered sandstones: either coarse, or from a delta shoreface, or from an oolithic platform.

Cooling ages of detrital zircons indicate three main peaks in lower Cretaceous, Trias to lower Jurassic and Paleozoic (ranging from 101 to 145, 190 to 242 and 288 to 434 Ma, respectively). Those peaks are interpreted as cooling ages of the detrital sources. They roughly coincide with, respectively: (1) the lower Cretaceous Equatorial Atlantic rifting, (2) the Central Atlantic Magmatic Province event at the Trias-Jurassic boundary and the subsequent Central Atlantic Rifting and (3) the Panafrican exhumation. Cristallisation ages inferred from $^{206}Pb/^{238}U$ dating of detrital zircons are mainly distributed around 650 Ma and may indicate detrital source from the panafrican belt in West Africa, prior to the opening of the Equatorial Atlantic. These findings allow to discuss the subsidence of the northern edge of the Demerara plateau, and to propose new relationships between the formation of the Demerara Plateau and the Central Atlantic Magmatic Province, based on a magmatic nature and Mesozoic age of the Demerara basement.

INTERACTIONS BETWEEN FORELAND BASIN AND COLLISIONAL WEDGE IN THE WESTERN ALPS: NEW SEDIMENTOLOGICAL, STRUCTURAL AND THERMOCHRONOLOGICAL DATA

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The Western Alps are key places to investigate the relationship between the collisional crustal wedge and the foreland basins. However, this area has been relatively less studied from this perspective. Thus, first-order questions remain unanswered: Why is the Western Alpine molasse basin (i.e., French side) much smaller than the Northern Alpine molasse basin (i.e., the swiss molasse basin)? What is the internal structure of this western basin? Are there any "sub-basins"? What is the precise age of initiation of the thrusts of the external zones? What are the current directions and the corresponding reliefs? What is the budget between accreted, eroded and deposited material?

The structural sequence of the External Alps is relatively well known, especially in the fold-andthrust belt between the External Crystalline Massifs (ECM) and the foreland basin. However, the thermal history of the ECM and the sedimentary record in the "sub-basins" remains to be documented in details.

We focused our study on the Oligo-Miocene basins between Grenoble and Geneva for which field stratigraphic logs are presented. This approach is completed with the interpretation of seismic profiles available in this area. New paleogeographic maps will be compiled to discuss the chronology of deformations in the basin. These data will be coupled with thermochronological data (ZFT and ZHe of the ECM and detrital rock samples) in order to more accurately date the thermal and structural history of ECM and the internal zone.

These data will allow to understand the links between the evolution of the Alpine collisional wedge and the dynamics of the foreland basin for which the timing and the localization of deformation are critical parameters, parameters that are very different in the Western and Central Alps.

BIOGENIC CARBONATE ACCRETION IN SUBMERGED KARST CAVES (BLUE HOLES) IN THE BELIZE BARRIER AND ATOLL REEF SYSTEM UNDER CHANGING METEORIC AND MARINE CONDITIONS

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Cryptic microbial carbonates are important components of postglacial tropical coral reefs in that they may form large parts of the rock volume and contribute to reef consolidation. A late Pleistocene to Holocene submerged speleothem from the Blue Hole on Lighthouse Reef Atoll (Belize) exhibits a complex history including a meteoric core and two marine phases (aragonite crust; serpulid-micrite outer crust) as a result of postglacial flooding of the karst cave. The core of the stalactite has a tufaceous texture and contains microbial remains, consists of low-magnesium calcite, and formed 19.55-10.68 kyr BP. The marine aragonite crust consists of stacked botryoids with crystals up to 700 µm long and dark crystal terminations enriched in high-magnesium calcite. The aragonite crust accreted from 10.82-9.95 kyr BP in shallow, warm water. Carbonate accretion rates averaged 125 µm/yr. The crust shows a dense, laminated texture on one side and a porous, shrubby texture on the other side. The presence of n-C16:1w5, n-C17:1w6, and 10Me-C16 fatty acids in the laminated crust suggests that sulfate-reducing bacteria contributed to aragonite formation in a less open environment than during formation of the porous crust, where these biomarkers are lacking or are less abundant. Enrichment of ^{34}S and ^{18}O in carbonate-associated sulfate (CAS) compared to seawater sulfate is also compatible with sulfate reduction during carbonate formation. The greater contribution of heterotrophic processes to aragonite precipitation in the laminated crust is also reflected in $\delta^{13}C$ values as low as -1.3‰. A pronounced isotopic variability and excursions to positive $\delta^{13}C$ values as high as +3.5‰ indicate an episodical, local impact of photosynthesis on aragonite precipitation. From 4.39 kyr BP, a biogenic crust of abundant serpulids and finely crystalline, microbial and detrital carbonate, consisting of highmagnesium calcite and aragonite, accreted at the outer margin of the stalactite. A similar facies occurs in the form of biostalactites in a submarine karst cave in the Belize Barrier Reef. Petrographical, mineralogical, and geochemical data suggest that sulfate-reducing bacteria played a substantial role in carbonate formation in this case too. The bacterial involvement in carbonate authigenesis is indicated by the content and isotopic composition of carbonate-associated sulfate, the presence of non-isoprenoidal sn-1-monoO-alkyl glycerol monoethers (MAGEs) and terminally-branched fatty acids, and the observation that the majority of molecular fossils assigned to sulfate-reducing bacteria is tightly associated with the carbonate mineral lattice. The Belize biostalactites are composed of four carbonate phases including serpulid tubes, lithified sediment, microbial carbonate, and unconsolidated sediment usually found in macroborings of bivalve molluscs. Lithified sediment and microbial carbonate are fine-grained with clotted and peloidal textures. Serpulid tubes are aragonitic, lithified sediment and microbial carbonate are mixtures of high-magnesium calcite and aragonite. Magnesium-calcite content increases with increasing consolidation. Lithified sediment and microbial carbonate are interpreted as fine, biodetrital sediment that was subsequently cemented by authigenic micrite. Our studies exemplify that heterotrophic bacteria can be a crucial agent that contributes to the formation of carbonate build-ups by cementing skeletal frameworks in cryptic environments.

FLOOD-EVENT RECONSTRUCTION IN ALPINE LAKE GROSSSEE (FLUMSERBERG, SWITZERLAND)

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Flood-events are amongst the most frequent and destructive natural hazards. As it is still highly uncertain how the occurrence of floods especially in mountain regions, will change in our era of climate change, it is essential to study controls and occurrences of such past events overl ong time scales. In this study, the lake sediments of Lake Grosssee (Flumserberg, Switzerland) are targeted to provide a several thousand years long record of flood-events. Grosssee is an Alpine lake at an elevation of 1617 m a.s.l. The lake has a surface area of 0.05 km^2 and a maximum water depth of 11.5 m. The lake catchment of 2.2 km^2 lies in the Helvetic Alpine nappes and consists partly of the Permian volcaniclastic Verrucano and the Triassic Quarten formations, which together provide the characteristic reddish colour of many parts of the catchment. During a flood event, these sediments are mobilized from the catchment and carried into the lake where they are expected to build distinct reddish flood layers providing thus ideal conditions for a flood-event reconstruction.

In February 2017, five sediment cores with lengths between 70 and 100 cm have been recovered from the lake basin. The sediment cores generally show dark black to brown and partly laminated sediments intercalated by reddish layers of different thickness. The blackish and brownish sediment sections contain 10-16% carbonate and 5-9% organic matter and are interpreted as hemi-pelagic background sediments. This background sedimentation is intercalated with reddish sediment layers, composed primarily of siliciclastics with normal gradation. These layers are interpreted as turbidites deposited during flood-events with a high content of siliciclastica. The carbonate content ranges from 22-55% and organic matter from 2-5%. At least 9 flood-event layers have been identified in the uppermost meter of the sediments coinciding with some historically known flood events.

In summer 2017, one long sediment core of ~10 m length will be taken in addition to the five short sediment cores. This long sediment core will help to improve the understanding of triggers, magnitudes and frequency of flood-events recorded in Lake Grosssee in the past several thousand years. The aim is to gain insights not only in the local flood frequency but also the flood intensity. In order to distinguish between a human-induced change in sediment availability from the catchment and a climate signal recorded in the lake sediments, an estimation of erodibility and its change over time is necessary. Volumetric and possibly palynologic analysis of the sediments are expected to provide the required information.

COMPARATIVE OBSERVATIONS ON SEDIMENTARY CHARACTERISTICS AND PROVENANCE INDICATORS, INCLUDING CATHODOLUMINESCENCE DATA, OF CERGOWA SANDSTONES (OLIGOCENE) FROM TWO LOCALITIES IN THE OUTER CARPATHIANS OF POLAND

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The Cergowa Beds form a lithostratigraphic unit within the Menilite Formation (Oligocene) in the Outer Carpathians of Poland. In the Silesian Nappe, at Skrzydlna quarry, the succession that contains the Cergowa Beds consists of three contrasting facies associations. A sequence of black shales with subordinate thin beds of turbidite sandstones is followed by an olistostrome complex overlain by F-U turbidite succession of the Cergowa Beds. The olistostrome consists of unsorted, chaotic sandy-wacke matrix hosting cobbles, boulders and rafts of slump-deformed sandstones. The Cergowa-Beds sequence above begins with thick, pebbly, medium-to fine-grained sandstones with rare mudstone interbeds. The sandstones are massive or display "coarse tail" grading evolving upwards into planar and/or cross lamination only in the top parts of beds; some beds contain dunes. The sandstones are petrographic equivalents of the underlying olistostrome matrix but are finer grained, relatively well sorted, contain usually oriented fine and well-rounded pebbles and are lacking carbonate grains. Gradually, these strata pass upwards into finer-grained and thinner sandstones intercalated with mudstones, organized as complete Bouma sequences and containing abundant calcareous grains, which are absent in the strata below.

The turbidite complex records a broad range of sediment gravity flows. Very little matrix and orientation of pebbles and granules in the lower parts of beds suggest deposition from "traction carpet"high density turbidity current with damped turbulence. In massive intervals (Ta of Bouma sequence), deposition occurred as a result of aggradational settling. The top-of-bed features represent "'classic" turbidity currents and traction-related Tbc intervals. Thick, gravel-bearing sandstone beds imply proximity to the source area; however, considering differences in grain roundness, two sources of the material should be considered. Finer grains, higher proportion of mudstone interbeds and mineral composition of calcareous quartz arenites in the upper part of the succession indicate deposition from diluted turbidity currents, and marine transgression in the source area evolving from siliciclastic to mixed silicilastic-carbonate shelf.

The Cergowa sandstones exposed in the Dukla Nappe consist of thick, medium– and fine–grained sandstone beds that represent high-density turbidity currents in the W part of the depository. Features of some bed sets suggest deposition by homogeneous and fluctuating sustained/hyperpycnal turbidity flows. Thinner sandstones with Bouma sequence and thicker mudstone interbeds farther to the SE represent low– density distal turbidite facies. Observations under the cathodoluminescence revealed a variety of lithoclasts: microbreccia, tectonised immature calcarenite/wacke, microsparite and sparite, packstone and dolostone. These grains provide new insights into the composition of the Silesian Ridge, which acted as the source area located to the NW of the Cergowa depository. They can be divided into two groups. The first group includes grains derived from the fringe of the provenance area (packstone and zoned dolostone). The second group includes lithoclasts resulting from erosion of tectonised parts of the provenance area (microbreccia and tectonised immature calcarenite/wacke) and its tectonically intact segments (microsparite and sparite). Comparison between the two areas documents parallel trends of evolution of two separate source zones of the Cergowa Beds detritus: uplift followed by formation of carbonate shelves.

RELATIONSHIP BETWEEN AUTHIGENIC MG-CLAY AND MICROBIALITES IN THE LACUSTRINE BALBUENA IV SEQUENCE, NE ARGENTINE

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The association between authigenic magnesium clays and carbonates has been reported for several lacustrine deposits, and interpreted to result from abiotic precipitation from alkaline lake waters. However, the role of microbial organisms (mainly bacteria) in forming these deposits remains contentious. A number of studies have shown substantial quantities of dissolved metals can be adsorbed by bacteria extracellular polymeric substance (EPS), and bacterial activity can lead to the production of mineral phases, which, over time, could result in the construction of geologically significant deposits. This study characterizes mineralogical paragenesis related to chemical driven and biological influenced precipitation of microbialites and associated authigenic clays of the Balbuena IV sequence of the Salta Basin.

In the Cretaceous and Early Paleogene Yacoraite Formation, Salta Basin, northeast Argentina, extensive deposits of lacustrine microbial carbonates and mixed carbonate-clastic sediments show cyclical bedding alternation, related to climate control. Four sequences (Balbuena I to IV) are recognized, the last of which was developed during a tectonic sag phase and thus is laterally extensive, with beds that correlate for over one hundred kilometers. In the lower Balbuena IV, calcareous rocks are more abundant, being related to driest environmental conditions. Facies include microbialites, grainstones and mudstones. The microbialites are laminated and micro-columnar structures composed of grumous, micritic and crystalline internal fabric, locally with spherulites and authigenic Mg-clay with sparse rhombohedral dolomite, and also euhedral fluorite, barite, Celestine and anhydrite. The upper interval of the Balbuena IV sequence is characterized by agglutinant microbialite intercalated with fine to sand siliciclastic rocks and is interpreted to have been deposited under seasonal wetter climates, which allow increasing the amount of siliciclastics grains in rainy periods and development agglutinant microbial facies in dry periods.

The understanding of chemical and biological aspects controlling the formation of authigenic magnesian clays, their mineral paragenetic association and the relationship with climate suggest precipitation of Mg clay within microbialite formed under a dry climate. The comparison between clays inside microbialites (authigenic high crystalline filamentous magnesium clay) and clays from fine facies (detrital low crystallinity ilite, smectite and analcime) indicates distinct clay textures. Integrating this information with facies association allow us to relate the occurrence of magnesian clays at high frequency regressive hemicycles in the sequence bottom and detrital ilite/smectite at high frequency transgressive hemicycles from entire sequence.

BASIN MARGIN STRIKE VARIABILITY ALONG A 70 KM STRIKE TRANSECT: TANQUA DEPOCENTRE, KAROO BASIN, SOUTH AFRICA

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The interaction of numerous sedimentary processes at key transition points along the depositional profile results in a complex heterogeneity in ancient basin margin successions. This complexity is generally well studied along depositional dip sections, but lateral (strike) variability and consequent implications for sediment distribution and stratigraphic architecture is commonly less well constrained.

In the Karoo Basin, continuous NW-SE-oriented exposure over 80 km has been characterized by 53 logs with 9910 m of cumulative thickness, > 2500 palaeocurrent measurements, and ground-and helicopter-based photo panels. Palaeoflow indicators suggest dominant sediment transport was to the N-NE, with E-W and NE-SW bidirectional components. These are consistent with a strike orientation of the outcrop belt relative to the margin progradation direction.

In the south of the study area, upper slope and shelf edge parasequences (50-75 m-thick), show current ripples and inverse-to-normal grading in micaceous and organic-rich siltstones and sandstones. They are interpreted as river-dominated prodelta and mouth bar deposits, locally incised by distributary channels (< 25 m-thick, 700 m-wide). Parasequences are partly truncated by upper slope gullies (10s of m-thick) and shelf-incised canyons (> 100 m-thick, 1.5 km-wide). Overlying shelf parasequences are thinner (15-50 m) with symmetrical ripple tops, HCS and low angle cross bedding, interpreted as wave-influenced deltaic or shoreface deposits. They transition upward into erosive-based, fining-up sandstones and isolated sharpbased tabular climbing-rippled sandstones, interpreted as channels and crevasse splays within delta plain mudstones. Along strike to the north, upper slope parasequences are thinner, show abundant wave reworking indicators and no evidence of gullying or incision. Their overlying shelf parasequences are sandier, more amalgamated and strongly influenced by wave action. They are interpreted as offshore, shoreface, foreshore and strandplain deposits.

Southern nearshore environments were therefore more river-dominated with bypass and sediment delivery to deeper parts of the basin across a steep, more erosive margin. Waves and storm current redistribution towards the northern, lower gradient margin resulted in higher net-to-gross and sand connectivity on a wider shelf, without major incision, bypass and sand supply to the upper slope. No evidence of major avulsions in the upstream tributary and distributary systems are interpreted because the bypass, fluvial-dominated characteristics are persistent in the southern areas through time, whereas the northern margin maintains a sand-starved upper slope and a wave dominated shelf succession.

The overall thicker and delta-dominated succession in the south, and the thinner, more condensed and wave dominated stratigraphy in the north are interpreted to be controlled by a combination of basement configuration and differential basin margin physiography. However, relative sea level fluctuations controlled the stacking patterns, with an overall shallowing-upward profile that can be subdivided into two prograding phases, separated by a transgressive event. In the smaller parasequence scale, climate, autocyclicity and dynamics between coastal processes influenced the equilibrium between sediment input, redistribution and compensational stacking. This study demonstrates that although basin margin successions may be consistently progradational, the interaction of mixed coastal processes and differential spatial configuration results in a complex along-strike sedimentary architecture, with major implications in sediment distribution through time and space.

SHALLOW SHELF CALCARENITIC DEPOSITS UNDER TIDAL INFLUENCE: FACIES AND ARCHITECTURE OF CARBONATE TIDAL BARS. EARLY TORTONIAN, AGUA AMARGA BASIN, (SE SPAIN)

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Superb exposures of tidal-dominated bioclastic calcarenites occur in the post-orogenic Agua Amarga Basin, infilling a complex paleomorphology over Neogene volcanic basement. A sedimentology, sequence stratigraphy and paleogeography study was made for the lowermost section of the basin fill (early Tortonian) and detailed descriptions and interpretations were also focused on the calcarenitic tidal-bar architecture along depositional dip direction.

There are two major facies associations: 1) volcanic and volcano-sedimentary mixed facies: sandstones and volcanic or volcanic-carbonate conglomerates and 2) carbonate-dominated facies: coarse- to medium-grained, bryozoans, mollusks, foraminifera, echinoids and red algae calcarenites-calcirudites, with muddy laminations. Interpreted depositional environments include the entire range from fluvial floodplain and alluvial fans; aeolian dunes and fan deltas of mixed volcano-sedimentary deposits; to muddy supratidalintertidal flats and shore, intertidal estuary channels; intertidal to subtidal bar complexes; barrier islands and washover-fans made of calcarenites with a minor volcano-clastic component.

The embayment morphology of the basin amplifies the tidal action and the control on sedimentation of tidal bars. The area was protected, confined and restricted and for this reason the tide-dominated calcarenite deposits are well preserved. The whole spectrum from finer-grained bottomsets, to coarser-grained calcarenite foresets and topsets was analyzed in terms of sedimentary facies, bed configuration to depict the semi-diurnal cyclicity and the seasonal cyclicity. Abundant bryozoan debris in the calcarenite indicate a significant input of marine grains likely introduced by storms and-or flood in the mini-basin later intensively reworked by ebb-dominated currents, the main contributor leading to the overall progradation architecture the tidal complex during the HST.

The ichnofabrics also indicate the abundance of Bichordites and Cylindrichnus interpreted as burrows produced by sea-urchins and sponges respectively, these trace makers both point to marine-influenced sedimentation rather than fluvial-influenced processes, in agreement with the allochems indicative of more opened marine origin.

Analysis of stacking pattern and detailed correlation within the early mini-basin fill supports sequence analysis and the interpretation of systems tracts: (1) fluvial facies refilling preexistent valleys over the volcanic basement (LST); (2) intertidal facies, washover fan or ebb-deltas towards the west, filling the spaces exceeding the volcanic paleohigh thresholds (TST); (3) more open and unconfined environment with subtidal facies prograding (HST+FSST); (4) barrier island and estuary fill (west directed paleocurrents, associated with closed environments; LST+TST); (5) and finally capped by a regolith (paleosol) in the lows and palaeokarst in the highs (FSST+SB) prior to major transgression recorded by a bioclastic shoal and chalky deeper marine facies (TST).

In essence, the studied outcrops have diagnostic features highly characteristic of predominant tidal settings; these cannot be described or referred to as a wave-dominated beach complex.

GEOPRESSURE CHARACTERIZATION AND MODELING: PRELIMINARY RESULTS ASSOCIATED WITH GRAVITY TECTONICS AND DRILLING WELLS IN FOZ DO AMAZONAS BASIN

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The dynamics of pore fluid pressure within marine sediments plays a key role in the stability of continental margins and it is an issue of major concern on hydrocarbon exploitation. Fluids include those trapped during deposition, or generated by geochemical processes (e.g. oil and gas), which migrate in response to sediment compaction. Due to the low permeability of fine-grained marine sediments, pore fluid pressures may not able to dissipate developing zones of overpressure and inducing gravity tectonics – detachment surfaces formationand instability zones (failures, landslides and tsunamis), implying great hazards for drilling operations. This study aims to better understand the mechanisms of overpressure generation in stratigraphic sequences and to determine their relationship with gravity tectonics focusing on the post-rift sedimentary record (Upper-Cretaceous to Recent), in the Foz do Amazonas Basin, Brazilian Equatorial Margin. Foz do Amazonas Basin is one of the preeminent basins in the world to study pore pressure evolution as clastic fluxes sedimentation associated with fast burial can control large-scale extensional and compressional structures recording gravity tectonics. In order to understand the origin of pore fluid overpressure and their effects on the basin, this study proposes an innovative integration of methodologies involving both 2D seismic interpretation and a set of geomechanical and basin numerical modeling. A structural restoration allowed us to build a 2D geological model. The 1D pore pressure, rock's strength and stress field modeling were built using available geophysical borehole data from 3 offset wells, including: density data, resistivity and compressional transit time and then they were calibrated with drilling events (pore pressure, rock strength and fracture gradient). This 1D geomechanical model calibration together with the 2D restoration allowed us to use a 2D geomechanical model to reproduce the full deformation of the basin and understand the evolution of stresses. The results expected from this geomechanical study are to predict the pore pressure with greater reliability and identify possible causes of detachment surfaces formation. In the future, petroleum systems modeling will be performed to integrate the results of geomechanical models, and thus to calculate the pore pressure evolution through time, including the generation of hydrocarbons.

A HIGH-RESOLUTION HOLOCENE RECORD OF PAST STORMINESS AND COASTAL DYNAMICS: FILSØ LAKE, WESTERN DENMARK

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Possessing long and accurate archives of past storm events is one key towards a better understanding of the atmospheric patterns driving these latter and of how coastal systems reacted in the past to changing forcing mechanisms. During the last decade, several Holocene storminess chronologies have been based on aeolian inlfluxes within coastal lakes and mires. These data have been suggested to adequately complement the data provided by the proxies of storm activity usually used in the coastal zone, notably because of their different sensitivity to local morpho-sedimentary dynamics.

This study presents a high-resolution (centennial to multi-decadal) history of Holocene past storminess over the North Sea reconstructed from a coastal lake of Western Denmark that formed after the closing of a bay and subsequent coastal progradation. Past aeolian activity and storminess are reconstructed using aeolian sand inputs preserved within the organic-rich lake sediments. Sand content is measured within centimeter-thick slices while the paleo-environmental context and the sediment sources are provided by XRF measurements and grain-size analyses. High-resolution chronological control is based on radiocarbon and OSL datings.

Our data demonstrate that high-frequency variations of aeolian sand influx have taken place between ca. 5000 and 2800 yrs B.P. that we suggest adequately reflect the changes in storm activity at that time. A massive sand invasion is observed around 4200 yrs B.P., in complete accordance with the first period of dune building that took place along the western coasts of Denmark, simultaneously to a period of climate deterioration widely recognized elsewhere in Europe and globally. The signal then slowly fades-out, most probably reflecting coastal progradation and dune fixation. On top of the insights these new data bring on the recurrence of past storm events, our results also question the interdependencies between past aeolian activity, morpho-sedimentary dynamics and relative sea-level.

RECORDS OF SMALL SCALE DELTAIC ENVIRONMENTS IN JURASSIC WITHIN A CONTINENTAL RIFT BASIN: KOTA FORMATION, INDIA

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The Pranhita-Godavari is a continental rift basin that hosts one of the sedimentary successions of Indian Gondwanas. These 4-5 km thick syn-rift sediments are dominantly siliciclastic and they were deposited between the Late Carboniferous and Cretaceous mainly by fluviatile processes. Occurrence ofan Early Jurassic limestonebed (known as Kota limestone) in this succession signifies that during the transition from the Triassic to the Jurassic period the prevalent fluvial depositional environment gave way to a carbonate precipitating wetland system. However, the sedimentary record of the environments that prevailed during this changeover has not yet been fully addressed in existing literature. This work presents the sedimentological features of the c. 100 m thick, siliciclastic sediments that immediately underlie the Kota limestone bed and reconstructs the transitional environment(s) within this rift basin.

Medium to fine-grained arenitic sandstones, mudstones and sand-mud heteroliths are the main lithological constituents of this succession. The lower fluvial part of the succession is characterised by several thick sandbodies with erosive basal bounding surface grading up to thinner massive red mudstones. The massive mudstones contain pedogenic features and thin marl beds. The sandbodies are characterized by the presence of large-scale cross-strata and a typical finning upwards grainsize trend. The transition from the fluvial domain is marked by gradual decrease in overall grainsize and increasing occurrence of laminated green mudstones and heterolithic units. The basal bounding surface of the bodies in this transitional part is typically planar and sharp. The internal organization of both the sandbodies and the heteroliths is characterized by the presence of offlapping sigmoidal packages produced due to progradation of the mouth bar complexes. The clinoformal strata are internally planar and trough cross stratified. The mean plaeo-transport direction is oriented sub-parallel to axis of the basin. Heteroliths show the presence of current ripples, wave ripples and wavy bedding. Soft sedimentary deformation is common, especially in the sandy units. The associated distributary channel deposits are made up of cross-stratified carbonate grainstones. Several characteristics of a fluvial deposit is missing in this part of the succession, including concave-upward basal bounding surface of the sandbodies, concentration of coarse clastics in the basal part, fining upward character of the sediments, etc.

Further up the succession, the clinoformal deposits grades into horizontally laminated deep-green mudstones devoid of any pedogenic features. The bed-geometry and other sedimentological features of these laminated mudstones and shales indicate deposition in basinal (shallow) environment. These basinal sediments grade upwards into palustrine-lacustrine carbonates.

The above observations suggest that small scale delta-like environments developed in between the fluvial and wetland domains within this continental rift basin.

THE EVOLUTION OF THE OLIGOCENE FLUVIO-DELTAIC ENVIRONMENTS OF THE SALIN BASIN, MYANMAR

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This research defines the Oligocene Shwezetaw, Paduang, and Okmintaung formations of the Salin sub-basin of the Central Myanmar Basin (CMB). This work aims to reconstruct the siliciclastic sedimentological systems observed in the area and to generate architectural models of the linked depositional environments. Data has been collected through a comprehensive field-based campaign, which studied well-exposed sediments along a basin-margin transect (north to south) which was approximately one hundred kilometers in length. Sedimentary logs, detailed panels, and subsequent petrographical analysis will allow for a better understanding of both the spatial and temporal evolution of the depositional systems.

The Salin sub-basin is a forearc basin formed during the Eocene. It is bounded to the north by the Himalayan foothills, to the west by the Kabow Fault Zone and to the east by the Sagaing Fault Zone. The sedimentary cover exceeds 10,000 m in places, which can be identified through limited 2D seismic data. Throughout the Oligocene, the north of the Salin sub-basin was mostly dominated by terrestrial depositional environments, whereas sea-level variations affected the basin towards the south through periodic marine incursions. This, combined with palaeocurrent data, suggests that the depositional systems were running from north to south, although there is some evidence of routing from the fault-controlled highs towards the east and west.

The Shwezetaw Formation in the north is basally formed from thick fluvial sandstones which grade into interbedded marine siltstones and sandstones up-section. To the south, the formation is predominately formed from fluvio-marine siltstones with rare interbeds of sandstone. Overlying this, the Paduang Formation, in general, is much more marine in nature. Although there are limited channelised fluvial sandstones can be observed in the northern most limits of the basin, these rapidly grade in fluvio-deltaic and then marine deposits towards the south. This suggests an overall transgression throughout the Lower Oligocene. By the deposition of the Okmintaung Formation in the Upper Oligocene, the deposits are interpreted as tidallyinfluenced deltaic facies, with very little spatial and temporal variation. This suggests that sea-level was relatively stable at this time.

After deposition, an east-west compression has generated a far reaching north-south running anticline which transects the CMB. This, in combination with the interbedded thick sands and silts, means that this area is of interest for petroleum exploration. The reconstruction of these Oligocene depositional environments, and the generation of models highlighting the evolution of these systems, can aid in the understanding of these underexplored plays. This work will also provide the basis for an ongoing study into the provenance and routing pathways of the sedimentary systems.

A 4.5 MY RECORD OF PALAEOENVIRONMENTAL CHANGES ACROSS THE JURASSIC/CRETACEOUS BOUNDARY (LÓKÚT SECTION, TRANSDANUBIAN MTS, HUNGARY): LITHOGENIC INPUT, PALAEOPRODUCTIVITY AND CLIMATIC TRENDS

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Lókút section (north-western Hungary) is precisely dated with calpionellid, nannofossil and magnetostratigraphy. The thickness of the section is ca. 13 m. It comprises a succession of pelagic limestones, ranging from the upper part of the Lower Tithonian (magnetozone m21r, *Parastomiosphaera malmica* Zone) to the lower part of the Lower Berriasian (M18r, *Calpionella alpina* Subzone). Sedimentation rates amount to 1 – 3 m/My during the Tithonian and 5 – 7 m/My in the Berriasian. New chemostratigraphic and stable isotope data are presented, integrated with chronostratigraphic framework. Geochemical proxies (Al, K, Rb, Th and magnetic susceptibility) suggest a decreasing input of terrigenous elements and increasing carbonate productivity during the Early Tithonian and the Berriasian. Increasing magnitude of enrichment factor (EF) of K toward the top of the section, as well as decreasing magnitude of Th/K peaks and aluminium sedimentation rate might indicate long term aridization trend. Slight oxygen depletion at the sea bottom (decrease of Th/U ratio) is observed upsection. However, low concentrations of Mo, and only slight enrichments in U and Co suggest dysoxic conditions only. Large increase in concentrations of productive elements (P, Ba, Ni, Cu) is observed starting from the lowermost part of magnetozone M19n2n (*Crassicollaria* Zone, Upper Tithonian) towards the top of the section. The abrupt rise in phosphorus accumulation rate correlates with a decline of Saccocoma and appearance calpionellid dominated microfacies. A peculiar feature in the Tithonian interval, is decoupling between carbonate $\delta^{13}C$ trend and P burial rate. A long-term decline in carbonate $\delta^{13}C$ values throughout the Lókút section reflects a global trend and is correlated with increasing carbonate productivity. Increasing delivery of nutrients under decreasing detrital input, indicates that upwelling must be considered as the most likely mechanism for nutrient transport. Palaeotopographic situation of the Lókút section, on the elevation slope, might additionally favor upwelling activity. Phosphorus accumulation rate correlates well with *Nannoconus* bloom which indicates that the abundance of the nannoconids was dependent on nutrient availability. Together with Nannoconus, an increasing occurrence of *Conusphaera* and a decline of *Watznaueria* and *Cyclagelosphaera* are also observed above magnetozone M19r.

INTEGRATED GEOLOGICAL PROCESS MODELLING: USING FORWARD STRATIGRAPHIC AND DIAGENETIC MODELLING TO BETTER ASSESS RESERVOIR ARCHITECTURE AND GEOMECHANICAL PROPERTIES

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Estimate the distribution of geological heterogeneities is a major challenge for subsurface exploration and reservoir characterization. Carbonate deposits usually host very good reservoirs but also subtler stratigraphic traps. They can form in various depositional environments, stratigraphic and structural settings, and can be affected by many different diagenetic processes. As a result, they present very heterogeneous petrophysical and petroacoustic characteristics and are difficult to image and interpret even using up-to-date seismic data. Assessment of stratigraphic traps require to develop novel integrative approaches to better understand the regional-to-local sedimentological and diagenetic processes, which have shaped source rocks, reservoirs and seals.

The challenge of our study was to develop and run a fast and accurate workflow combining wireline log interpretation, detailed sedimentological and diagenetic studies, with deterministic stratigraphic forward and synthetic seismic modelling of a carbonate reservoir (average thickness of about 200 m) at an appraisal scale (650 km^2, using a grid point spacing of about 200 to 500 m). A review of lithofacies classification (facies type and facies group) and GDE definition (Gross Depositional Environments), allowed us to define stratigraphic parameters such as accommodation space, carbonate production rates, sediment transport parameters, dissolution-cementation rates, ... A series of numerical simulations were performed using the DionisosFlow stratigraphic model to simulate sedimentological and diagenetic processes through geological time. The simulation results were used to estimate geomechanical and petroacoustic properties. Convolution of this rock property model with a synthetic wavelet made it possible to compared simulation results to seismic data. Finally, sensitivity analysis was performed to evaluate the impact of stratigraphic and diagenetic processes on the seismic signal.

We illustrate this workflow by simulating a shallow water Miocene carbonate platform. We show in particular that this forward stratigraphic, diagenetic and seismic modelling workflow made it possible to better understand the impact of sedimentary and diagenetic processes on large-scale carbonate reservoir properties and finally to reduce uncertainties on the appraisal-scale reservoir characterization.

ARCHITECTURE, DYNAMICS AND EVOLUTION OF A DELTA DEPOSITED IN A PIGGY-BACK SYN-FOLD GROWTH CONTEXT: THE MIDDLE EOCENE SOBRARBE DELTAIC COMPLEX(SOUTH-PYRENEAN FORELAND BASIN, ARAGON, SPAIN)

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The Sobrarbe deltaic complex series overlies the top of the Gavarnie-Sierras exteriores thrust sheet in the Ainsa subbasin part of the central South-Pyrenean foreland basin. From middle Lutetian to Bartonian times the frontal thrust propagation towards the southwestern foreland leads to SE-NW progradation of the Sobrarbe deltaic system that are mainly controlled by the SSE/NNW trending Buil syncline. The Sobrarbe deltaic complex represents the late infill of the piggy-back stage of the Ainsa subbasin. In this context, accommodation is the sum of: i) eustacy; ii) regional flexural subsidence and iii) local relative uplift related to minor folds. This study is based on the acquired detailed geological maps (1/5000) of facies and stratigraphic surfaces, about seventy measured sections and chronostratigraphic data.

The analysis of three dip sections shows three third-order sequences (SI, SII, SIII) of about 800 Kyr. The SI Highstand systems tract architecture is characterized by both growth strata geometry and a thinning of deposit thickness towards the E/W trending Mondot intrabasinal anticline. Later on, the deltaic system progradation is enhanced due to the growth of the Mondot anticline in the more proximal areas. This reduces accommodation and favors erosive and bypass processes supplying deeper portions of the basin away from the anticline. Thus, a falling stage systems tract is recorded, bounded at the top by a sequence boundary expressed by a highly erosive river surface near the Mondot anticline top. Further northwest, still under the influence of the anticline growth, a basinward shift and a greater accumulation of the delta front facies are recorded in association with the sequence boundary. At deeper and distal areas, where accommodation is much greater (no anticline growth), this sequence boundary is not easy to recognize because an aggradational succession of distal delta front and prodelta facies is developed during relative sea level fall and initial rise. The tectonic activity and the greater accumulation of foreset deposits triggered collapses on the Mondot anticline flanks. These collapse scars are the preferential routes for sedimentary transfer from proximal to distal part of the deltaic system, and/or preferential space for the foreset deposits. Thick turbiditic sandstones should be deposited in deep basin conditions as has been observed in SII.

Above the before-mentioned sequence boundary, a transgression is recorded away from the Mondot anticline before the SII generalized progradation. This transgessive event is less important when approaching the anticline. Low accommodation rates associated to the anticline growth avoid the development or mask this transgressive event.

This example shows how the fold growth in relatively close areas of the same subbasin may control locally the accommodation rates and subsequently the sequential arrangement in different sections, highlighting the sequence boundaries (erosion, bypass, progradation and basinward shift) in anticline areas and making them diffuse in time-equivalent high accommodation areas away from these folds. Conversely, transgressions will be not developed or masked on the anticline areas because low accommodation rates.

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DEVELOPMENT AND INFILL OF THE LATE ALBIAN TO TURONIAN SHILAIF-NATIH INTRASHELF BASIN AT THE EASTERN MARGIN OF THE ARABIAN CARBONATE PLATFORM (UAE, OMAN)

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Organic-rich carbonate deposits may become source rocks and be considered as unconventional reservoirs in specific conditions. During the Late Albian to Turonian, the regional distribution of organicrich sediments in the Middle East was controlled by the development of intrashelf basins within extensive shallow-marine carbonate platforms.

Regional sequence-stratigraphic and biostratigraphic correlations between Oman (Natih Fm.) and Abu Dhabi (Mauddud, Shilaif and Mishrif Fms) have allowed to better constrain the location and evolution of these intrashelf basins through time, explaining the lateral and vertical variability of source rock facies today.

This study confirms that the Shilaif-Natih intrashelf basin was initially created by differential aggradation of shallow carbonate deposits during a phase of significant increase of eustatic sea-level and tectonic stability (Late Albian). However, the evolution of this basin, i.e. the nature and rapidity of its fill, was then clearly influenced by regional very low-amplitude structural deformation processes.

During the Early Cenomanian, high carbonate production and large wavelength folding favored the rapid fill of the Natih E intrashelf basin until subaerial exposure in Oman, while the Shilaif intrashelf basin remained unfilled (Lower Shilaif Mb.).

During the Middle Cenomanian, the aggradation of the Natih D & C shallow carbonate platform was affected by very low-amplitude and large wavelength folding, possibly preventing intrashelf basin development in Oman, while very few sediments were deposited in the Shilaif intrashelf basin of Abu Dhabi. Subsequent uplift led to subaerial exposure in Oman and probably as far as the “LekhwairArch” area (Top Natih C). In the Shilaif basin, organic-rich deposits were then mixed with clays coming from the exposed areas, probably leading to lower source-rock quality (Middle Shilaif Mb.).

During the Late Cenomanian, tectonic stability and a significant increase of global sea-level led to a new phase of intrashelf basin development by differential aggradation in Oman. High TOC organic-rich sediments accumulated in the deepest part of the basins (Natih B, Upper Shilaif Mb.). Then the carbonate fill of the Natih B basin was affected/forced by an important phase of structural deformation in Oman, due to the onset of the ophiolite obduction process. Significant uplift and structural deformations occurred in Oman and on the “Lekhwair Arch”, providing clay sediments which progressively filled the Shilaif Basin (Tuwayil Fm., Late Cenomanian-Turonian transition?). Carbonate sedimentation continued in the still subsiding western and south-western part of Abu Dhabi (Turonian) as well as in Iran (Sequence 4 of the Sarvak Fm.).

This combinationof stratigraphic and structural wedges as well as erosional truncations has created complex geometries of sequences, difficult to predict and correlate at the regional scale.

GLOBAL AND LOCAL FORCINGS ON SEDIMENT DISTRIBUTION OF THE SW GULF OF LIONS (NW MEDITERRANEAN)

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The SW termination of the Gulf of Lions (GoL) is characterized by a narrowing shelf (from 80 km in the central part to ca. 20 km at the French/Spanish border), increased hydrodynamic processes and lowered sediment supply. It has been the target of a relatively large number of high-resolution seismic and acoustic investigations, as well as grab sampling, but few long cores are presently available because relatively low sedimentation rates (compared to the central GoL) did not attract the interest for paleo-environmental studies.

In preparation of a map of surficial sediments in this area, a compilation of available data was undergone. In dip section, beyond the littoral prism, 4 distinct morpho-sedimentary units are at the origin of submarine landscapes. From W to E, they include:

(1) between20 and60 m,

(2) between 60 and75 m, a relict, 2 to 5 m-thick mud wedge, highly eroded, that can be assigned to the Younger Dryas by analogy with similar, thicker features described and well-dated further to the east;

(3) between ca.75 m and100 m, a set of stacked thickening seaward forced-regressed Systems Tracts linked to 100 ky and 40 ky glacio-eustatic cycles. They consist of over-consolidated muds from paleo-prodeltas and lower shorefaces, and to sand bodies reworked into large dunes, drapped by a veneer of recent muds. These sands are locally cemented and form elongated reliefs at the position of paleo-shorelines (beachrocks). A characteristic of unit 3 in that part of the GoL is that, because of important reworking by hydrodynamic processes, sequences assigned to Marine Isotope Stages (MIS) 6.2, 6.4 and 7.6 are outcropping at some places, in contrast with the central GoL where they are buried underneath a 20-50 m interval of MIS 3-MIS 2 sediments.

(4) between ca.100 m and the shelf edge (that ranges between110 and170 m depending on the distance from canyon heads), normally consolidated offshore muds forming a wedge up to 150 m where accommodation is sufficient (infilled canyon heads).

In summary, the distribution of surficial sediments in the GoL is, in general, largely controlled by the history of sea-level changes and the position of point sources. More specifically, the western termination of the GoL exemplifies the major role of hydrodynamic processes in modifying the position and water depth of boundaries between different sedimentary units and sequences.

GREENHOUSE VS ICEHOUSE: IS IT THAT SIMPLE? EXAMPLES FROM THE JURASSIC AND CRETACEOUS

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It is widely accepted that the climate system can be split into two end members: greenhouse and icehouse. The Jurassic and, in particular, the Cretaceous are routinely classified as greenhouse devoid of significant continental ice. However, almost all sea-level curves generated for this time period contain large amplitude, high-frequency events that appear to cast doubt on the icehouse/greenhouse paradigm. Moreover, both physical and proxy evidence for Mesozoic ice sheets is growing, including the presence of dropstones and glendonites, dramatic shifts in sea water temperature as expressed in stable isotopes, orbital-forcing signatures in the rock record, and the results of global paleoclimate simulations. Such glacioeustatic events play a key role in the formation of specific, predictable, global sedimentation patterns, some of which have petroleum system significance. Using global data synthesis of geological data combined with the results of paleoclimate simulations, this communication explores three of these examples.

The first example is from the Aptian when distinct sedimentation patterns developed, dominantly controlled by high-amplitude fluctuations in sea level and modulated by local climatic and tectonic conditions. The early Aptian transgression resulted in the deposition of worldwide source rocks (oceanic anoxic event [OAE] 1a), including in shallow, carbonate-dominated, intra-shelf basins. During the following longlasting late Aptian lowstand, low-latitude carbonate platforms were exposed, karstified, and incised. In higher latitudes, siliciclastic lowstands were deposited. In the opening South Atlantic, thick evaporates developed at this time, forming the seal of the subsalt play.

The second example is from the Valanginian, which is characterised by large-scale, prograding successions punctuated by high-amplitude sea-level fluctuations. This caused worldwide valley incision and shedding of sands along the basin margins. Carbonate systems of this age show evidence of karstified tops, a faunal crisis, and biota turnover, which affected reservoir qualities.

The final example involves exploring Early Jurassic when a transgression similar in amplitude and pace to the early Aptian led to the deposition of another worldwide source rock during the Toarcian OAE. This was preceded by a globally recognized lowstand in the late Pliensbachian for which tantalising evidence for high-latitude ice exists, supported by the results of our paleoclimate simulations.

These examples demonstrate specific, globally recognised stratigraphic patterns developed in response to large amplitude, high-frequency sea-level changes. To identify these sea-level fluctuations and understand their nature, duration, and link to other global events, an integrated, worldwide approach is necessary, including both the shallow-water realm, which provides, for instance, physical evidence for the amplitude of sea-level changes, and the deep-water record, characterized by continuous bio-and chemo-stratigraphic datasets. In addition, climate modelling will be an important support to develop a better understanding of the subtle relationships that controlled sedimentation during, what is for now named, “greenhouse times”.

ESTUARINE CLAY MINERAL DISTRIBUTION: MODERN HOLOCENE ANALOGUE FOR RESERVOIR QUALITY PREDICTION

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Primary-depositional mineralogy is a dominant control on the distribution of clay-mineral cements in sandstones, which may either enhance or degrade reservoir-quality. Fe-Mg enriched chlorite grain coats can preserve anomalously high porosity in deeply buried sandstones reservoirs through the inhibition of authigenic quartz cements. In contrast, pore-filling illite and kaolinite typically reduce reservoir quality through porosity and permeability reduction. The objective of this study is to better understand the distribution of clay minerals within marginal-marine sandstones by using an analogue modern estuary. X-ray diffraction was performed on the fine fraction (< 2 µm) of surface samples (< 2 cm), and estuarine cores (< 15 m) in order to understand the fundamental processes that govern clay mineral distribution throughout the Holocene succession. Surface clay mineral maps and shallow cores show i) detrital chlorite is most abundant in the outer estuary (foreshore, backshore and tidal inlet), ii) illite is most abundant within the inner and central estuarine tidal flats, and iii) kaolinite displays a relatively ubiquitous distribution. Hinterland geology and climate (weathering intensity) control clay mineral type and abundance. Surface clay mineral distribution is predominantly controlled by estuarine hydrodynamics. Clay mineral type and abundance throughout the Holocene succession is largely controlled by changes in relative sea-level and the transition from an open, tidal-dominated setting, to an enclosed/sheltered wave-dominated system. The uniquely high resolution dataset with transferable fundamental controls on clay mineral distribution allows for the prediction of reservoir quality on a stratigraphic, reservoir-scale basis.

INTERACTION BETWEEN RIVER, UPLIFT AND TRANSVERSE SEDIMENTATION: EXPERIMENTAL RESULTS AND APPLICATION TO THE BENGAL BASIN

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Inalluvial systems such as foreland basins, mass is commonly injected either laterally by transport from source regions, or vertically from below via local uplift. We report results on the competition between these two fundamental processes, using an experimental basin with a deformable substrate. The lateral supply is via two alluvial fans on orthogonal walls of the basin; the uplifting region is downstream of one of the fans (axial source) and opposite to the other (transverse source). We show that the presence of a transverse sediment input increases the erosion rate of the uplifting region by pushing the mixing zone between the two alluvial sources against the uplifting mass. However, increase in sediment delivery to the transverse fan does not cause a proportional increase in erosion rate of the uplifting region. Instead, the system reaches a steady state balance between uplift and erosion induced by the transverse fan, such that there is no change in the total mass above the active alluvial surface a lateral analog of the classical steady state between vertical erosion and uplift. We also show that the mixing zone is instrumental in limiting upstream aggradation and funneling sediments to the shore, resulting in limited river lateral mobility and increased progradation. Hence, the interaction between alluvial sources buffers the erosion and lateral mobility of rivers. In the Ganges Brahmaputra Meghna delta, such dynamics may have participated in the stabilization of the Brahmaputra River course in the Jamuna valley during Holocene time.

A HYBRID APPROACH TO FACIES MODELING: COMBINING OBJECT MODELING WITH PLURIGAUSSIAN SIMULATION (PGS) BASED ON A HIERARCHICAL FLUVIAL ANALOGUE DATABASE

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Facies modeling of fluvial deposits is notoriously challenging for geomodellers. Fluvial deposits are characterized by their highly variable, and therefore unpredictable, lateral and vertical facies distributions, which make it difficult to generate realizations that honor the trends in data (wells, seismic) while also adhering to common geological rules. A variety of (stochastic) facies modeling algorithms are currently being used in the industry, however, individual algorithms all have their difficulties in accurately capturing fluvial complexities. These complexities are a first order control on reservoir heterogeneity impacting both permeability and porosity, and any derived volume and performance estimates bases on such models. Here, we present a novel hybrid, hierarchical approach that combines object-based facies modeling with a plurigaussian algorithm, with input parameters extracted from an advanced hierarchical fluvial analogue database called "FAKTS".

The Fluvial Architectural Knowledge Transfer System (FAKTS) database stores literature-and field-derived data on fluvial sedimentary units from more than hundred field analogues in a hierarchical and relational manner. It characterizes fluvial elements at three different scales of observation and classifies them according to controlling factors and context-descriptive characteristics. In our hybrid approach, raw data from the database are transformed into quantitative parameter input that can be directly used to populate the settings of object-based and pixel-based plurigaussian facies modeling algorithms in commercially available reservoir modeling software. In the first step, an object-based facies modeling algorithm is used to populate the reservoir with sedimentary units (channels, point bars, splays), whereby the geometry and dimensions are constrained using analogue-derived data. In the second step, a pixel-based plurigaussian algorithm is used to model the internal heterogeneity of the sedimentary units. The Plurigaussian algorithm requires indicator variograms and a truncation diagram to be defined. Indicator variograms are constructed from the facies dimensions, proportions, and transitions stored in the analogue database. Similarly, the truncation diagram is constructed from the analogue-derived facies transition statistics to ensure that the contact relationships (lithotype rules) between fluvial sedimentary units are honored.

This novel hybrid approach allows smaller-scale heterogeneities (architectural element-scale) to be modeled with a plurigaussian algorithm within object-modeled larger-scale depositional elements to more accurately represent fluvial reservoir heterogeneity. As a result, key variables affecting economics, such as connected reservoir volume and flow performance, are better constrained and therefore potentially more useful. A case study of a 'braided' fluvial reservoir succession, offshore NW Australia, penetrated by 5 wells, is used to demonstrate this novel approach.

CENOMANIAN-TURONIAN BOUNDARY EVENT BOUNDED BY TWO TECTONIC PULSES, LARGE-SCALE SEQUENCE STRATIGRAPHY APPROACH SHOWS

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The $\delta^{13}C$ positive shift of the Cenomanian-Turonian Boundary (CTB) has been proven (1) to be correlatable worldwide and (2) to be recorded in basinal and platform carbonates as well. It is therefore an invaluable stratigraphic tool to correlate the high-frequency depositional sequences occurring around the Cenomanian-Turonian boundary on a large scale, and to check for the correlatability of relative sea-level (RSL) changes.

Sequence stratigraphy analyses in west-European, north-American, north-African and Middle-East shallow-water depositional settings, combined with litterature data, show that the CTB event (CTBE), as defined by the isotope shift, is bounded by two particular stratigraphic surfaces that can be, each, either sequence boundaries (RSL fall) or transgression surfaces (RSL rise) or non existent (no RSL change) depending on places. The sequence stratigraphic heterogeneity is interpreted as the result of two short-lived tectonic pulses bounding the Event. Regarding the peri-Tethyan area, the data suggest a pulse in the Africa vs. Europe convergence, especially well recorded along the Syrian Arc and in the westen French Alps. The fact that such a move is coeval with renewed thrusting in the Sevier Belt of North America, as well as evidences of uneven tectonic behaviour along the eastern North Atlantic margin, suggest that the pulses could be global. The large scale of such coeval tectonic disturbances therefore questions the commonly acknowledged slow-paced state of tectonic processes.

The CTBE is mostly known by the widespread occurrence of black shales in Atlantic to Tethyan basins (Oceanic Anoxic Event 2, or OAE2), although (1) an extensive literature survey shows that the stratigraphic range of Cenomanian to Turonian black shales is a little more complex from deep basins to marginal settings, and (2) data from the Pacific Ocean are scarce. A large number of geochemical studies have proposed different interpretations for the environmental changes possibly linked to the organic matter enhanced production and/or preservation at that time. Among them, is the influence of a burst of global volcanic activity (so-called Large Igneous Provinces, or LIPs). Our data could be in support of such an internal cause, although ongoing research suggests that other large-scale similar pulses are not accompagnied by $\delta^{13}C$ isotope shifts, nor black shales.

DISTRIBUTIONAL REGULARITY AND CONTROL FACTOR RESEARCH OF PHYSICAL PROPERTIES OF PRE-SALT LACUSTRINE CARBONATE RESERVOIRS: AN EXAMPLE OF IARA OILFIELD, SANTOS BASIN, BRAZIL

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IARA Oilfield is regarded as one of the richest petroleum-bearing areas within Santos Basin, and the reservoirs are almost entirely discovered in the pre-salt formations formed in the rift-subsidence lake basin during the early Cretaceous. As the relationship of porosity and permeability cannot be perfectly explained by linear model so that parameter FZI is adopted to build up predictive calculating model for the different flow units. By analyzing the crossplot composed of estimated porosity and permeability, the conclusion can be drawn that the distribution of physical properties of the reservoirs is mostly controlled by the sedimentary facies. In the ITP section, for the intershoal lake shares the most of microfacies, the values of porosity and permeability that distribute in the range of 3-9% and 5-20mD respectively are relatively smaller, while rise up in the BVE300 section presenting in a larger range of 3-12% and 10-25mD because many parts of the microfacies convert to the grain banks when lake level is falling. With the transgression, more fine grained sediments start to deposit in the BVE200 section, thus the storing capability of the reservoirs for the fluid becomes lower. In virtue of the porosity and permeability distributed in 9-18% and 14-40 mD, the development degree of reservoir pores for the BVE100 section is considered as the highest one, particularly the values from the northwest-southeast belt in the west structural high of the area that can reach up to 20% and 89 mD. The conclusion manifests the fact that almost all the excellent reservoirs are formed in the BVE100 and their qualities are getting poorer with the depth increasing. The reason for such variation is complicated. For the BVE100, along with the rising-up of the hydrodynamic force and temperature during the regression, the degree of dolomitization is becoming stronger, which results in bigger pore spaces of microbial reefs, and meanwhile the cements and impurities that the shale and clay are dramatically reduced by the water flushing, and the pore and throat system presenting with the powerful storing and filtering capability, hence, is formed. As the lake level for the BVE300 or ITP is always staying in a relative high stage, fine grained sediments come to be the main deposition owing to the weak hydrodynamic force in order that many pores and throats are inevitably blocked up with the shale and clay which show the great negative effects on fluid filtration. Some places, however, present with the unexpected features of abnormal high porosity and permeability, probably for the reason that the quality of original pore and throat system is positively improved by the hydrothermal erosion occurred in the rift stage or the dissolution caused by acid liquors which were produced from the source rocks and transferred within the fractures formed during the tectonic movements. Therefore, the favorable exploration zones are preferred to select in the BVE100 section, and other sections can be treated as the second choice.

LIMITED IMPACT OF CLIMATIC CHANGES ON SEDIMENTARY SYSTEMS

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Numerical evolution models have been widely developed in order to understand the evolution of landscape over different time-scales, but also the response of the topography and stratigraphic architecture to changes in external conditions, such as tectonics or climate. However, the sources (areas of sediment production) and the sinks (areas of sediment deposition) are often studied separately. Here, we use an enhanced version of Fastscape, a very-efficient model solving the stream power equation, which now integrates a sedimentary basin at the front of a relief, to explore the response of a sedimentary system to changes in precipitation rates. Because the sediments are the ultimate archives of landscape evolution, we focus on parameters that are relevant for stratigraphic studies: the sediment flux and the geometry of the deposits.

We show that based on the stream power law, changes in precipitation rates can only induce transient perturbations of the sediment flux, because the system is able to get back to a steady state configuration in a few million years. It thus appears that high spatial and temporal resolutions are required to identify changes in precipitation rates in the source areas based on a stratigraphic record.

LIMNOGEOLOGICAL RECONSTRUCTIONS IN SUBTROPICAL SOUTH AMERICA USING HIGH-ALTITUDE LAKE SEDIMENTS AT THE ARGENTINEAN EASTERN CORDILLERA

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Subtropical South America east of the Andes provides an ideal setting for limnogeological reconstructions to understand changes in past atmospheric circulation patterns. Previous paleolimnological research in Northwestern Argentina has been carried out in meadows, proglacial, playa and landslide formed lakes. However, the regional correlation of the reconstructed climate oscillations remains highly controversial. The lack of agreement between these reconstructions has reinforced the interest to pursue a regional limnogeological analysis to evaluate the synchrony or lack of it among lacustrine systems located at different latitudes. In particular, the Eastern Cordillera from Argentina (22°-26°S) has a strategic position at the southern limit of the South American Monsoon system (SAMS), which regulates the precipitation in large areas of the subtropics. We have initiated a multiproxy study of sedimentary cores retrieved in high altitude (> 4000 m a.s.l.) shallow lakes (< 2 m water depth) located in different environments from Zenta and Santa Victoria ranges. Combined micro-sedimentological, geochemical and mineralogical investigations will be used to identify climatic transitions and abrupt events during the Holocene. Laguna Salada Grande (23°S/65°W) is a shallow lake (~1.5 m water depth) with an endorheic watershed located at 4100 m in the Zenta range. Paleoshorelines situated several meters above the present lake level indicate the occurrence of major paleohydrological changes. Preliminary analyses revealed the deposition of different facies: a) banded and laminated, organic dark sediments; b) finely laminated light sediments; c) massive inorganic green sediments; and d) massive inorganic clays. Sedimentary features such as the presence of organic rich sediments and tuff deposits can be traced from the cores into exposed profiles outcropping in erosion gullies and trenches around the lake, allowing to correlate and better understand the former watershed configuration. Despite its altitude, Laguna Salada Grande has not been glaciated during the Late Pleistocene permitting the comparison of its paleolimnological record with the cooling events reconstructed from glacial fluctuations reported at highest altitudes of the Eastern Cordillera. Our results from this study site will be compared to high altitude limnogeological records from other wetlands at Santa Victoria range and Altiplano-Puna region. These lacustrine records from Eastern Cordillera will supply novel and critical information that combined with former reconstructions from other subtropical archives will greatly improve existing scenarios of former SAMS activity at middle latitudes of South America.

DEEP SEA GIANT POCKMARKS ALONG THE BAHAMA CARBONATE ESCARPMENT: NEW INSIGHTS FROM THE CARAMBAR 2.0 CRUISE

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This study reports discovery of spectacular giant pockmarks alignment along the toe of the Blake Bahama Escarpment (BBE), a km-scale "cliff-shape" bounding the San Salvador abyssal plain (< 4500 m).

Submarine giant pockmarks (> 250 m in diameter) in deep carbonate settings have been poorly described in the literature so far. Their 4D-distribution, architecture and origins remain to be understood in order to accurately address fundamental and applied issues related to fluid transfer through sedimentary basins. Pockmarks alignments are commonly distributed above buried sedimentary bodies such as slope channel systems or related to buried fault systems releasing fluids through the overlying sedimentary column. Our study shows/discusses a new type of pockmarks alignment that has been observed thanks to the high quality bathymetric/seismic data of CARAMBAR 2.0 cruise (December 2016-January 2017).

The present-day morphology of the Blake Bahama Escarpment (BBE) has an erosional origin (~6 km of retreat, 2 km high) due to combined deep boundary contour currents, carbonates dissolution, bio-erosion and corrosive brines seepages. This erosional retreat overprinted a buried "bench-shaped" morphology exhibiting a relict 6 km-wide flat carbonate surface currently buried by sediments lying in the San Salvado Abyssal plain. The area is bathed by a deep contour current called the Western boundary Under Current (WBUC).

Data analysis revealed the presence of more than 30 giant pockmarks. Those depressions are elliptical in shape, can exceed 1800 m in diameter and form depressions ranging between 30 and 220 m. Seismic interpretations have revealed a vertical V-shape structure expressed by a seismic anomaly that is located 900 m underneath the seafloor depression. Seafloor fluid expulsions (i.e. expressed by pockmarks) either (1) occur where contouritic deposits are absent, or (2) vertically cross contouritic deposits. Accurate seismic analysis of this latter case does constraint 4D sedimentary filling of the studied collapse structures and emphasizes that contouritic sedimentation and cyclic fluid expulsions have probably been contemporaneous at least over a period of time. Accordingly, we propose two different conceptual models of pockmark initiation and growth based on (1) and (2) observations.

The studied pockmark alignment is parallel to the BBE cliff trend and related chains of pockmarks are systematically located right above the buried carbonate bench. Our observations therefore suggest that the pockmarks are genetically related to the buried bench in which the fluid source is most probably localized based on seismic anomalies recognition (bright spot, 900m in depth). Vertical fluid transfer occurs along fracture systems or blind faults forming vertical drains likely originated from fluid overpressure build-up and related V-shape break-up of top seals. Water column data and fluid nature have not been investigated at the moment, however, the whole geometry of the system shows similarities with the work of Paul & Neuman (1987) in which brine seeps have been recognized.

Our work highlights deep-sea pockmarks distribution, morphologies, architecture, and origins in carbonate settings and partly elucidates their atypical interactions with contouritic sedimentation.

A NEW PALEOTHERMOMETER FOR EVAPORITIC ENVIRONMENTS: BRILLOUIN SPECTROSCOPY

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The reconstruction of changes in Sea and Lake Surface Temperatures (SST and LST, respectively) is critical for our knowledge of past climatic changes. Most of these reconstructions are based on bio and or geochemical proxies. In ancient evaporitic basins however, where proxies based on fossil life are unusable, microthermometry on subsurface minerals fluid inclusions (FIs) appears to be the most adequate paleothermometry alternative. FIs are present in virtually all rock minerals, including halitea major constituent of evaporitic series, and are commonly used to constrain Formation Temperature (Tf) of crystals, via the microthermometry technique. This approach assumes that the vapor bubbles contained in biphasic FIs disappear, during heating, at a given Homogenization Temperature (Th) corresponding to the FI Tf. Halite samples generally contain monophasic FIs, hence they are cooled in a freezer to nucleate a vapor bubble in the FIs, prior to gradually heating them to reach the Th. Although this technique is widely used, it also faces several limitations. First, bubble nucleation is an unpredictable and scarce event. Second, the observed values of Th in a single sample form a broad distribution, covering a wide temperature range; this may be due to damages caused by cooling. The latter is the main limitation of the microthermometry approach. Conflicting views about the true formation temperature are found in the literature: some authors recommend to use the mean of the Th distribution, others its maximum. We have used FIs in synthetic and natural halites to demonstrate the potential of a novel technique, Brillouin spectroscopy, in determining the formation temperature of fluid inclusions in evaporites. The main asset of this new method is that it is free from the above limitations because it does not depend on the formation of vapor bubbles. The use of both Brillouin and microthermometry techniques on the same samples of synthetic halites has confirmed the advantage of Brillouin spectroscopy and its extended use on natural evaporites. Indeed, in contrast to microthermometry, the Brillouin technique gives a narrow distribution of Tf values (± 3°C), consistent with the known precipitation temperatures of the synthetic and natural samples. Brillouin spectroscopy thus provides a unique tool for SST and LST reconstructions in evaporitic sequences.

SOURCE TO SINK STUDY AT CONTINENT-SCALE (AFRICA): MANTLE DYNAMICS CONTROLS AND IMPLICATIONS FOR THE SEDIMENT ROUTING SYSTEM

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A source to sink approach was performed at the scale of a continent – African the frame of the TopoAfrica project, with three main objectives (1) the characterization of the relative importance of deformation (uplift) and climate (precipitation) (2) the quantification of the deformation, its nature and causes, (3) the effect of those deformations on the past African topography and on the sediment routing system. We mainly focused on Western, Central and Austral Africa, characterized by anorogenic relief (plains and plateaus) record of long (several 100 km) to very long (several 1000 km) wavelength deformations, respectively of lithospheric and mantle origin.

The sink measurement was based on the seismic stratigraphic analysis of numerous regional seismic lines (from the upstream part of the margin to the abyssal plain) merge of industrial and academic data, calibrated in ages and lithologies on reevaluated wells to get the best possible ages. Volumes measured between successive time-lines, were compacted for a comparison with solid eroded volumes. Uncertainties were calculated (including ages, time-depth conversion law, porosities...) using the Volume Estimator software.

The source study was performed using dated stepped planation surfaces (etchplains and pediplains) key morphological features of Africa mappable at catchments-scale. During Late Paleocene to Middle Eocene times, Africa experienced a very hot and very humid climate leading to the formation of an African-scale weathering surface (etchplain) known as the African Surface. This surface today deformed and preserved as large plains, domes or plateaus, can be used as (1) a marker of the very long wavelength deformations and (2) a reference level to measure eroded volumes since 40 Ma. Some other younger planation surfaces were also mapped of (1) Early Oligocene and (2) Late Miocene ages.

(1) Deformation (uplift) is the dominant control of the sediment budget. Climate (precipitation) changes only enhance or inhibit a deformation-controlled flux.

(2) The sources of clastic sediments are or closed marginal bulges or far field domes due to mantle dynamics with by-pass (transfer zones) along long-lasting polygenic surfaces located in between.

(3) Africa-scale deformations occurred during Late Cretaceous (Turonian-Coniacian) and around the Eocene-Oligocene boundary with a break contemporaneous of intense chemical erosion from 75 Ma and mainly from 65 to 40 Ma. Most of the African relief and topography are younger than 40 Ma. Late Cretaceous relief are only preserved in the Guinea Rise and the Southern African Plateau.

BIOMARKER AND INORGANIC GEOCHEMISTRY OF CRETACEOUS CARBONATE-BEARING MUDSTONE FROM JIUQUAN BASIN, NORTHWESTERN CHINA: IMPLICATIONS FOR THEIR ORIGIN AND PALEOENVIRONMENT

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Since the Xiagou Formation have been confirmed to be the main source rock of the discovered crude oil in Yumen Oilfield, geologists have completed lots of researches aiming at the sedimentology, reservoir, migration and accumulation of the petroleum rather than the enrichment mechanisms of organic matter in carbonate-bearing mudstone. In this research, the carbonate-bearing mudstone from the Xiagou Formation were analysed using synthetical organic and inorganic geochemical analyses to research the origin and paleoenvironment. Based on the analysis of organic geochemistry parameters, the bulk geochemical characteristics indicate that the carbonate-bearing mudstone in Xiagou Formation were deposited in a lacustrine environment with brackish water under suboxic to relatively anoxic conditions. For example, the preponderant of C27 steranes and abundant bicadinane, perylene reflect a mixed contribution of aquatic algae and microorganisms with a significant amount of land plant. Moreover, plentiful parameters such as Pr/ Ph, DBT/F versus DT/F indicate the significant redox condition is anoxic condition. The salinity of water column is relative with Gammacerane index and abundant β-carotene. According to the major oxides and trace elements of sediments, the high content of phosphorus (P) may show a high nutrient environment for aquatic algae and bacteria, corresponding to the volcanic eruption. Meanwhile, the ratios of trace elements such as Rb, Sr/Ba, V/Ni and Cu/Zn indicating the redox paleoenvironment of Xiagou Formation is suboxic to anoxic condition. Besides the ratios of Sr/Cu, Mg/Mn, Fe/Mn and SiO_2 versus(Al_2O_3+K_2O+Na_2O) suggest the analysed sediments were deposited during humid to semiarid paleoclimate condition. In conclusion, the carbonate-bearing mudstones of Xiagou Formation have a favourable organic matter preservation and organic matter input.

HYDROCARBON EXPULSION CHARACTERISTICS AND THE LOWER LIMIT OF TOC FOR EFFECTIVE LOW ABUNDANCE SOURCE ROCKS: A CASE STUDY IN SOUTH DONPU DEPRESSION, BOHAI BAY BASIN, CHINA

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According to the traditional appraisal theory for source rocks, the criteria of TOC for the effective source rock is 0.5%. However, source rocks with TOC lower than 0.5% occupies large percentage in southern part of Dongpu Depression based on the geochemical analysis. And oil-source rock correlation revealed that most hydrocarbons in discovered reservoirs are generated from these source rocks. Should the source rocks with low TOC be considered as effective source rocks when making estimation of reserves? Therefore, this paper aims to investigate whether source rocks with low TOC abundance expelled hydrocarbon in the geological time, and to set a new criteria of TOC for effective source rock in the southern part of Dongpu Depression.

For the determination of whether source rocks have expelled hydrocarbon, the method of "pyrolysis hydrocarbon ratio" will be used. In this procedure, the free hydrocarbon amount of the current source rock (S1) and the pyrolysed hydrocarbon amount of kerogen (S2) can be obtained through pyrolysis experiments. Besides, the original hydrocarbon amount of source rock can be simulated (S0). S0 will be compared with (S1+S2) to identify whether the source rocks have expelled hydrocarbon. For the criteria of TOC for effective source rocks, the material balance method which is based on theory of kerogen thermal degradation from B.P. Tissot and D. H. Welte will be used. This method establishes the relationship between residual organic matter content and original organic matter content by studying formation compaction, cumulative hydrocarbon generation, and hydrocarbon expulsion ratio. Then the evolution relationship between original TOC and Ro of source rocks will be obtained, which will indicate the lower limit of TOC.

Through the two methods above, it is suggested that 90% of type II and III source rocks with low organic carbon abundance (< 0.5%) in Xinanwa Sag and Gegangji Sag in south Dongpu Depression have expelled hydrocarbons. And the lower limit of TOC for effective source rocks is 0.25% for Type II and 0.35% for Type III respectively. Therefore, source rocks with TOC ranges from 0.25%-0.5% should not be neglected when we evaluate resource potential in South Dongpu Depression, Bohai Bay Basin. This method for evaluation of effective source rock and TOC recovery is recommended for other petroliferous basins especially for the area with low TOC abundance.

CHARACTERISTICS AND EFFECTING FACTORS OF PORE STRUCTURE OF HYPERSALINE LACUSTRINE SHALES: A CASE STUDY OF THE PALEOGENE SHAHEJIE SHALES IN DONGPU DEPRESSION, BOHAI BAY BASIN, CHINA

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The Paleogene Shahejie shale in the Bohai Bay Basin is a well-known hydrocarbon source rock for the overlying and underlying sandstones, and recent studies have focused on the hydrocarbon potential of Shahejie formation as an unconventional reservoir.

In this study, to understand the characteristics and the influence of pore structure of the shales in hypersaline lacustrine environment, a series of experiments were conducted on 26 Shahejie core samples from hypersaline environment in Bohai Bay Basin of China, including field emission-scanning electron microscope (FE-SEM) observation, low-pressure Nitrogen adsorption-desorption experiments, X-ray diffraction analysis, vitrinite reflectance analysis (Ro) and total organic carbon (TOC) measurement. Additionally, fractal analysis of the 26 shale samples was performed. Finally, the influence of the hypersaline lacustrine environment on pore structure of shales was investigated.

Conclusions are as follows: (1) The nanopores and micro-fracture of shales in hypersaline lacustrine environment are mainly developed in evaporite minerals. Hypersaline lacustrine shales in Dongpu Depression contain mainly carbonates, with an average of 51.9%, and the clay mineral content averages 25.2%. The dissolved intraparticle pores of bio-framework and the dissolved interparticle pores of calcite, dolomite and gypsum are the main nanopores type in shale samples observed by FE-SEM. In addition, microfractures half filled by calcite are largely developed. (2) A few mecropores developed in shale samples of hypersaline lacustrine environment, and the organic matter is not the provider for these mecropores. Similar to marine shales, the nanopores of these shales are dominated by mecropores with pore size ranging between 3.1-4.5 nm, but the average total pore volume (TPV) only occupied 58% that of marine shales. The average BET specific surface area (SSA) is 5.84 m^2/g, 43.7% that of marine shales. Although hypersaline lacustrine environment benefits to the preservation of the organic matter, the SSA and TPV of shales deposited there both show negative correlation with TOC. (3) The pore structure of larger pores is more complex, which is effected by the abundance of organic matter. For the hysteresis loop shape of the N_2 adsorption-desorption isotherms of 24 samples, 60 percent of it can be identified as type H3, and 40% is type H2, which illustrates pore structures of the studied shale samples are complex. Moreover, the surface fractal dimension varies slightly (2.43-2.66), whereas pore structure fractal dimension is scattered with high average, which indicates structure of larger pores is more complex.

Overall, in hypersaline lacustrine environment, containing a large amount of evaporite minerals results in shales being dominated by mecropores and microfractures, but the quantity of these mecropores is smaller than that of marine shales. The high abundance of organic matter in hypersaline lacustrine environment makes the pore structure of larger pores complex, but has no effects on the quantity of mecropores. Thus, as an unconventional reservoir, shales in Shahejie Formation are unlikely to contain commercial shale gas due to the limited quantity of mecropores, but are potential to be targets for shale oil because of widely developed microfractures and high abundance of organic matter.

A REVISED MODEL FOR TOC PREDICTION IN SHALES: A CASE STUDY IN LIUTUN SAG, DONGPU DEPRESSION, BOHAI BAY BASIN, EAST CHINA

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Shale oil resource is abundant in the Shahejie Formation in the Dongpu Depression. As for shale plays, it's commercial production is constrained to the area which called the "sweet pots". According to the "sweet pot" evalution criterion, the TOC content of shales is an essential element. Therefore, it's of great significance to do the TOC estimation for shales. Directly method, like pyrolysis, is expensive and time consuming. However, well-logging method can provide an economical and convenient mean to estimate TOC. From which, the most widely used is Passey's method. For the method, it assumed that there exists a linear relationship between logarithmic formation resistivity and sonic transit time, but this relationship can only be used within the zone which sonic transit time ranging from 262 us/m to 459.2 us/m, which makes it inapplicable for the estimation in some shale plays. In order to eliminate the limitation, we have derived a new relationship between logarithmic formation resistivity and sonic transit time from Archie Equation. And the ΔlogR has the following form: ΔlogR=log10(R/Rl)$^{+}$, where R is the reading resistivity of formation rock, Rl is the baseline value, m is the parameter from the Archie Equation, Δt is the reading value of sonic transit time, Δt m is the matrix sonic transit time of target shale, Δtl is the baseline value. The second limitation is that the interbedded fine sandstone-siltstone developed in shale intervals will make contribution to the TOC prediction. In the study, we found that the TOC contribution from interbeded fine sandstone-siltstone can be reduced when GR was ntroduced as a rock type indicator. Another drawback of Passey's method is that LOM used in Passey's method represents the level of organic metamorphism, and it requires a conversion between LOM and Tmax or vitrinite reflectance (Ro), which will be a problem in practice. Thus, we have replaced LOM with vitrinite reflectance (Ro) as the thermal maturity indicator. Consequently, our revised TOC eastimation model can be expressed by the following form: TOC=(a*ΔlogR+b(GR-GRl))*10(c+d*Ro). And the revised model has been used for the estimation in the Liutun sag, and the specific formula in this area is TOC=(2.53*ΔlogR+0.0015*(GR-GRl))*10(0.4786-1.10276*Ro). Compared to the correlation coefficient of 0.75 of previous Passey's method, the correlation coefficient of the revised method is 0.887. Thus, the revised model can provide a better TOC estimation.

APPLICATION OF GROUND-PENETRATING RADAR IN CHARACTERIZATION OF BRAIDED RIVER RESERVOIR CONFIGURATION

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Ground penetrating Radar (GPR) is a kind of broad-spectrum geophysical exploration technique, which is used to detect the distribution of the layers of underground medium. In this paper, the outcrop of Datong yungang braided river was taken as the goal. The application of GPR detection technology in characterization of fluvial facies reservoir configuration and establishment of prototype geological model were discussed thoroughly. In general, GPR detection technique and implementation process are composed by the acquisition of geological radar data in target areas, data processing and profile integrated interpretation. The core of this work focused on the analysis and interpretation of ground penetration profiles based on fluvial facies reservoir configuration and depositional model. By using different frequencies antenna combination, the configuration units of different depths and scales could be identified. However, the sedimentary channel of braided river migrates frequently, resulting that the channel presents the side-joint or superimposed relationship in section profiles, so it was difficult to identify in the radar section. In this study, the method of frequency decomposition was adopted to improve the resolution, side joint and superimposed relationships of channel in the section were identified. Through the target detection in Datong yungang region, four kinds of braided river sedimentary reservoir configuration units were identified, including the channel deposit, Diara deposit, abandoned channel deposit, flood plain deposit. The channel deposit has coarse granularity and generally consist of sandstone, there are usually gravels at the bottom. Such deposit forms a lens-shaped wave reflection in the radar profile with a flat top and convex bottom, and the attitudes of radar reflection direction axis above and beneath the interface are different. The Diara deposit mainly consists of sandstone, presents a convex-shaped wave reflection in radar profile. Abandoned channel deposit is generally composed of fine grained sediments, with the developmental location adjacent to the main channel sand body. The shape of wave reflection in the radar profile shows an obvious concave, and the internal reflections are relatively cluttered. Flood plain deposit is mainly composed by clay and silt, and the deposition process is relatively slow and steady, so it shows a weak reflection characterization with continuous and stable distribution in radar profile. Ultimately, the different kinds of geological radar response characteristics and the identification of configuration interface were summarized respectively, and the 3D prototype geological model of targeted braided river sedimentary was established.

PALEOENVIRONMENT AND PALEOCLIMATE OF NEOGENE SEDIMENTS IN SHALLOW SEA AREA OF NANPU SAG, BOHAI BAY BASIN, CHINA: AN INTEGRATED INORGANIC GEOCHEMICAL AND BIOMARKERS APPROACH

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Nanpu sag is one of the oil-rich basins in Bohai Bay Basin, China, and Neogene formations has been the focus target in shallow sea area. Geologists have completed lots of researches aiming at the stratigraphy, sedimentology, and reservoir and accumulation of the petroleum rather than the sedimentary dynamics, especially the chemical compositional variation of sediments which have close relationship with depositional paleo-environment. In this article, Neogene sediments are analyzed through inorganic elements analysis and the biomarkers analysis, thus to discuss the elements variation of Neogene vertical strata, paleo-climate change, paleo-salinity, and redox condition.

The element abundance of Guantao Formation is obviously lower than that of Minhuazhen Formation, and the element variation from the bottom to the top implies the Neogene climate change. According to the value of Sr/Ba, V/Ni, Sr/Ca, Fe/Mn, Rb/K, Guantao Formation and Minghuazhen Formation both belong to fresh water deposits of terrestrial fluvial environment with low paleo-salinity, as is verified by the biomarkers characteristics, including the high content of fluorenes and naphthalenes, and low content of Gammacerane index.

The inorganic geochemical parameters, including Cu/Zn, V/Cr, Ni/Co, U/Th, δUδEu, REE, La/Yb, indicate that Guantao Formation and Minhuazhen Formation of Nanpu sag were deposited in the redox paleo-environment of suboxic condition. Meanwhile, the biomarkers parameters, such as Pr/Ph, DBT/F versus DT/F also agrees that redox condition is suboxic.

Moreover, the ratios of Sr/Cu, Fe/Mn, Mg/Ca and $\delta^{13}C$ reveal that the analyzed sediments were deposited under semi-arid to arid paleoclimate condition. The absence of sodium salt precipitation and gypsum precipitation illustrates that the paleoclimate is far from extreme arid. However, the concentrations of Ti and Zr in Guantao Formation are a little higher than that in Minghuazhen Formation, reflecting the paleoclimate of Guantao Formation is a little more humid than that of Minghuazhen.

In conclusion, the Neogene paleoclimate of shallow sea area of Nanpu sag is relatively arid, but Guantao formation period is slightly more humid than Minhuazhen formation period. Neogene formations were deposited in terrestrial fresh water suboxic environment with low paleo-salinity.

JURASSIC-CRETACEOUS TUFF-SANDSTONES OF THE UST-BELSKY MOUNTAINS: COMPOSITION, GENESIS, SOURCES

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The territory of the Ust'Belaya Mountains belongs to the northwestern part of the Koryak-Kamchatka fold system. The region is characterized by a fold-thrust structure. We studied tuff-sandstones by petrographic and granulometry methods within different structure elements paraautochthon, allochthon and neoautochthon.

Paraautochthon. Paraauchthonous rocks belong to Algan terrain (J3kim-K1v) include volcanic-siliceous-terrigenous rocks. We find out two groups of tuff-sandstones within them. First group is located on northwestern part of territory, and was formed by higher-speed flows. They contain more igneous rock fragments with volcanic cement. Second group is located on southeast and composed of large fragments of tuff-siltstones with argillaceous cement. The size of grains from the first group are larger than the second one.

Allochthon. Allochthonous rocks belong to Ust'Belaya terrane, which consists of several tectonic sheets. We discuss only the Mesozoic flysch complexes, which were included in the northwestern Udachninskaya (K1) and, southeast Mavrinskaya (J2) sheets. Tuff-sandstones of the Udachninskaya sheet contain a larger amount of volcanic cement (20%), than tuff-sandstones of the Mavrinskaya sheet (5-7%). The grains of the Udachninskaya sheet are larger and worst sorted than the grains of the Mavrinskaya sheet. Tuffsandstones of the Udachninskaya sheet formed by higher-speed flows.

Neoautochthon. Neoautochthon is formed the Perekatnaya (K1al-K2t) and Lamut (K2cn-cp) formations. There are two groups of tuff-sandstones within the Perekatnaya formation. The first group have volcanic cements; the second group have argillaceous cement. The number of lithoclasts increases and the amount of quartz and feldspar decreases, the size of grains and the sort factor are increase from the southeast to the northwest in the rocks of second group. The deposits of the Lamut formation are characterize by gradational lamination. All studied tuff-sandstones are poor sorted and have bad degree of abrasion.

Conclusion:

a) Tuff-sandstones accumulated synchronously with volcanism of island-arc;

b) The change in the composition of tuff-sandstones and the size of grains determines the location of the sources in the northwest. The source of the paraauchthonous and allochthonous rocks was the Uda-Murgal arc (J2-K1). The source of the neoautochthonous rocks was more siliceous than the source of allochthon and paraarohotton, this source was the Okhotsk-Chukotka volcano-plutonic belt (K1K2);

d) All studied tuff-sandstones were formed by high-speed turbidites. Tuff-sandstones relate to sediments the continental river and coastal-marine facies rely on the excess ratio and asymmetry. However, high-speed turbidity currents were formed on a steep underwater slope, and coastal currents could sort the rocks well. Therefore, the accumulation conditions of material correspond to a moderately deepwater situation in marine conditions, near the shore. The sedimentation conditions can be correlated with the typical prodelta conditions or with the vicinity of delta and prodelta.

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EFFECTS OF TYPHOONS ON MORPHOLOGICAL CHANGES IN SANDY BEACHES AND IMPLICATIONS FOR PRESERVATION POTENTIAL

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On average, Korea is subject to at least one or more typhoon invasions each year. As a typhoon approaches, strong waves can considerably change the morphology of beaches, particularly located in the southern coast of Korean Peninsular rather than in the west facing opposite to the passage of typhoons. In order to understand typhoon effects on morphological and sedimentary changes in beaches, topographic profiling before and after typhoons has periodically been conducted. Haeundae beach, a popular beach in Busan, Korea was selected for beach profiling, these having been done along five monitoring transects using a VRS-GPS system. In addition, box-cores and sediment samples were collected to capture footprints of typhoons, all the evidence being used for evaluation of preservation of typhoon deposits in the records. According to the buoy data records located close to Haeundae beach, high waves with ~4.7 m of the significant wave heights and ~13.2 sec of wave periods on average during the typhoon Chaba landfall (6th October, 2016) were recorded. The average wave directions were 173 degrees, directly open to the beach. Repeated topographic surveys reveal that substantial erosion on beach face up to 1.9 m (1.2 m on average) occurred, and together the beach slope became much gentler from 5.3 to 2.5 degrees. Mean sizes in beach sands became coarser about 0.5 phi after the typhoon. Interestingly, wave-formed structures such as HCS and wave ripples were not observed based on facies analysis of box-cores taken after the typhoon. Although a destructive typhoon as revealed in the study, surprisingly the beach recovered much faster than expected. Within two weeks after the typhoon passed, two third of the beach recovered, thereby forming initial concave-up morphology. It has been no longer than three months to shape the beach complete. It can thus be said that the effects of typhoons are negligible at least on beach face, in spite of severe destruction by typhoons. In the sedimentary records, the typhoon activities remain only as the significant surface of erosion between beach laminations under normal condition, not as wave-formed any structures.

FIRST DIRECT FIELD OBSERVATIONS CONNECTING SUPERCRITICAL TURBIDITY CURRENT PROCESSES TO THEIR PRODUCTS

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Turbidity currents transfer sediments from the continental margin to submarine fans via channels; forming some of the largest sediment accumulations on Earth. It is suggested that submarine channel inception is due to erosive, supercritical turbidity currents that are common in proximal settings. Recent advances in direct monitoring of submarine processes have provided the first measurements of supercritical turbidity currents, demonstrating that they drive the upstream migration of crescentic bedforms on the seafloor. Although upstream-migrating supercritical bedforms are common in proximal settings across the world's oceans, there is considerable debate over the type of deposits that they produce. It is important to understand what types of deposit record these supercritical bedforms, and how those deposits are preserved, to potentially identify them from geological archives.

For the first time, here we combine direct measurements from supercritical field-scale turbidity currents with the facies and depositional architecture resulting from such flows. We show how the seafloor and subsurface architecture evolves after more than 100 flows in a highly active seafloor channel at Squamish submarine delta, British Columbia, Canada. Repeated upstream migration of bedforms is found to create two main deposit geometries. First, regular back-stepping beds result from flow deceleration on the slightlyinclined sides of the bedforms. Second, lens-shaped scours filled with massive deposits result from erosion of the back-stepping beds by subsequent turbidity currents. We suggest that these two types of geometries depend on aggradation rates. In particular, highly aggradational conditions are likely to preserve regular back-stepping beds, whilst conditions of low aggradation will only leave space for lens-shaped scours to be expressed in the deposits.

This study provides the first field-based diagnostic tool to identify proximal supercritical turbidity currents and their associated upslope-migrating bedforms in the sedimentary record. We relate our findings to a range of ancient outcrop studies to demonstrate that supercritical flows are common in proximal settings through the geological record. This is important for correctly identifying the proximal sites of ancient submarine channels that served as past conduits for globally significant quantities of sediment.

TECTONIC AND SEDIMENTARY EVOLUTION OF THE PLATFORM-IONIAN BASIN IN THE UPPER CRETACEOUS IN ALBANIA

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The objective of this study is to reconstruct the Upper Cretaceous evolution of the carbonate platform of Kruja and the Ionian basin in the peri-Adriatic region. The redeposited slope sediments of this platform-basin system represent one of the most important petroleum reservoir intervals onshore Albania, as well as offshore in Italy. During the Upper Cretaceous, the Ionian basin was extended along a NW-SE direction, bounded from the east and the west by the Kruja and Apulian platform, respectively. The tow prograding platforms were separated from the Ionian basin by a normal faults system created by the Lower Jurassic extension regime, which have been reactivated subsequently as thrust belt during the Alpine orogeny.

A detailed sedimentological analysis was carried out on the Upper Cretaceous outcrops in Albania including the Kruja platform sediments, likewise the basinal/slope succession in Kremenara anticline in the Albanian fold-and-thrust belt, in order to identify the different mechanisms that controlled the sedimentation in the Kruja platform and also to understand the relation between the platform context and the slope/basin reservoir facies. The study is based on 200 samples collected from the Kruja (Kruje-Dajt) platform and Kremenara anticline.

The Upper Cretaceous lithological succession of the Kruja platform is represented by 1244 m of shallow-water carbonates deposited in suptidal to supratidal environments. Sixteen different sedimentary and diagenetic facies have been identified in the Kruje-Dajt massif. A brecciated dolomite facies form the bottom of the stratigraphic section (260-m-thick).

The upper Cretaceous tectono-sedimentary evolution of the Kruja platform is determined by two different paleogeographic periods. These two periods are characterized by six types of high-frequency peritidal sequences (5^{th} to 4^{th} order) indicating a relative stability of the system.

During the Santonian-Upper Campanian period, the platform experienced subtidal to intertidal environments reflected by rudist facies. Bafflestone and Rudstone facies characterize the middle part (500-800 m) of the stratigraphic section, forming 4^{th} order cycles with rudist packstone and floatstone facies reflecting maximum rudist development conditions. The Late Campanian-Early Maastrichtian period points out a major change on the sedimentation marked by slumped packstone facies intercalated with stromatolite facies marking a period of destabilization on the platform. This period of destabilization limits the Upper Campanian-Lower Maastrichtian algo-bacterial facies that form emersive and sub-emersive sequences. The top of the succession reflects the regressive context of the platform during the Maastrichtian. To the west of the platform, the slope sediments consist of more than 200 m of proximal and distal calci-turbidite sequences deposited during the Campanian period. These calci-turbidites are intercalated with metric debris flow intervals reflecting important supply of calci-clastic material. In the upper part of the succession, three different major (~ 150-m-thick) slump events were recognized, the quantity of deformation suggests a tectonic effect for these destabilization periods during the Upper Campanian-Lower Maastrichtian, where the implementation of slumps resulting from the tectonic dismantling of the platform border. These periods of slumping are poorly recognized in the platform succession and they have a very limited presence (10-m-thick).

IMPACT OF SEDIMENTOLOGY AND DIAGENESIS ON THE RESERVOIR PROPERTIES OF THE UPPER CRETACEOUS CARBONATE FACIES IN ALBANIA. THE CASE OF THE KRUJA PLATFORM

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Carbonate reservoir systems are key targets to hydrocarbons exploration, CCS and CO_2 storage domains. Indeed, the difficulty of evaluating their reservoir properties lies in the fact that these properties are not only related to their depositional context but mostly to the complex diagenetic processes that affected them subsequently. The Upper Cretaceous carbonate sediments of the Kruja platform are a good example of oil-stained outcrops, where oil has preferentially impregnated fractures and porous matrix so it can be seen clearly on the surface.

Techniques used in this study include detailed sedimentological analysis carried out in the Kruja area (Albania), resulting in the study of 1244-m-thick succession of shallow marine carbonates. A macroscopic description was conducted, core plugs were collected in the field by using a core drill and thin sections of these core plugs were analyzed. Samples have been passed to a series of petrographic analysis (classical, cathodoluminescence and fluorescence petrography), geochemical analysis (trace elements, XRD and stable isotopes), and petrophysical analysis (Hg porosimetry, air permeability and NMR).

Porosity ranges from poor to very good (< 1% to ~20%) and permeability varies from low to good (< 1 mD to 40 mD). These reservoir characteristics are strongly related to the modifications caused by diagenesis, such as seafloor related processes taking place under shallow burial conditions, as well as meteoric diagenetic modifications in relation to exhumation. Early dolomitization was recognized in the upper part of the stratigraphic succession within peritidal sequences. The fine-crystalline (< 100 µm), planar-e (euhedral) dolomite recognized shows dominant intercrystalline porosity, with porosity and permeability values 15 – 17% and 35 – 40 mD. The lower part of the stratigraphic succession consists of a dolomitic breccia unit characterized by non-planar dolomite crystals (xenotopic), with dominant intracrystalline porosity generated by a dissolution phase. Hg porosity values were between 4 and 17%, with K= 0.8 – 6 mD. The secondary porosity in this interval is mostly related to hydrothermal fluids karstification. This is proofed by the presence of peculiar mineral phases such as saddle dolomite, bright luminescent blocky calcite cement and depleted $\delta^{18}O$ values (-12.4% –-7.1%PDB). Best porosity values were found in partially dolomitized packstone–grainstone facies, where bioclast mineralogy was replaced by planar dolomite texture euhedral-e and important secondary porosity development. Hg porosity values were between 12.9 and 20.3%, while the low permeability values (2.7 – 3.2 mD) relate to the non-connected pore networks.

In conclusion, diagenetic processes play an important role in increasing of reservoir quality of the studied succession. However, cementation and dissolution had both negative and positive effects on reservoir properties, respectively. The $\delta^{18}O$ and $\delta^{13}C$ values of the bulk sediments range between5.5 and 2.4% PDB, and 0.6 and 3.2% PDB, respectively. These values mostly reflect marine signatures, although some alteration is likely. The more negative $\delta^{18}O$ values of the cements can be explained by precipitation at elevated temperatures during increasing burial, or within shallow-burial environment under the influence of meteoric water. The negative $\delta^{13}C$ values of some calcite cements (-7.8% PDB) reflect the reducing conditions of the parent geofluids.

INTEGRATED WORKFLOW FOR CHARACTERIZATION AND MODELING OF AN OUTCROP ANALOG OF PRE-SALT SERIES: INSIGHTS FROM THE YACORAITE FM., SALTA RIFT SYSTEM (NW ARGENTINA)

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Outcrop analogues are key elements in the understanding of reservoir architecture and heterogeneities. Indeed, accessible subsurface data often represent an extremely small fraction of the reservoir complexity. This is specifically true for carbonate reservoirs that exhibit a high degree of lateral and vertical heterogeneity, whatever the scale of investigation. Working on subsurface data without the benefits of relevant outcrop analogues and their studies based on field observations, may therefore lead to important misinterpretation of well or seismic data. These questions are particularly important in the study of continental carbonates (lacustrine, travertine...), in which the heterogeneity distribution is drastically different from classical and well-known models for marine series.

Based on world-class outcrops, the aim of this study is to present an integrated workflow from characterization to modeling of the Yacoraite Fm., a mixed lacustrine succession (Maastrichtian-Danian in age) deposited in a sag setting (Salta rift basin, Argentina) and to illustrate different applications of outcrop analogue studies: 1) definition of conceptual relationships between several geobody types; 2) quantitative characterization to describe the dimensions and geometry of geobodies; 3) building of user-cases to calibrate modeling parameters and to design modeling workflows.

The Yacoraite formation records an overall transgressive trend from syn-rift fluvio-aeolian sandstones passing upward to mixed lacustrine deposits, in turn overlaid by post-rift lacustrine dark shales with gypsum, anhydrite and halite. More than one hundred sedimentological sections have been logged in the whole basin (~200 x 200 km) to assess the spatial distribution of each facies and their sedimentary architectures, at both basin and reservoir scales. The large-scale lake in the Alemania-Métan sub-basins) occupying the Salta rift exhibited different depositional profiles depending of the location in the basin. We also established a typology of microbial facies and characterize their lateral / stratigraphic distribution using statistical analysis.

The quantitative approach carried out in this study has enabled us to use a large variety of data in a modeling workflow: the spatial characteristics / length scales / quantitative relationships between sedimentary facies are key elements for the modeling phase. These parameters were completed by the integration of 3D Digital Outcrop Models (3D photogrammetry) that provided constraints for the building of the surface model and grid at intermediate scale. Such a quantitative database constitutes the basic building blocks of an integrated reservoir modeling workflow (stochastic simulation), that aims at reproducing the distribution of fine-scale heterogeneities related to microbialite facies. The bi-plurigaussian geostatistical algorithm used in this study enabled us to perform complex modeling of multiple variables and finally to account for subtle reservoir heterogeneities.

CHARACTERIZATION OF THE LACUSTRINE SERIES OF MIOCENE AGE AS MARKERS FOR CLIMATIC AND TECTONIC REGIONAL EVOLUTION OF THE EAST AEGEAN REGION

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Lacustrine sedimentary systems register the complex and intricate behavior resulting from 1) physiography evolution, related to local soil conditions (fixing by vegetation, alteration and erosion); 2) environmental parameters (temperature, precipitation, wind, volcanic events...); 3) sedimentary processes (biotic and abiotic); and finally 4) active tectonics from local to regional scale. Therefore, they constitute some of the more complete and best preserved records of the past environmental conditions. The fundamental issue addressed in this project corresponds to the unraveling of these forcing parameters on the development and demise of carbonate-dominated lacustrine systems.

We intend to address these issues by studying field analogues and subsurface data, focused on continental and lacustrine series of Miocene age located in the Eastern Aegean region, outcropping in Samos and Chios islands. The Aegean/Anatolian region has long been a premier laboratory for studying mechanisms controlling the deformation of the upper plate in subduction zones. Meanwhile, these series developed during one of the main climatic and biologic crisis (the Messinian climatic crisis) provide a fantastic archive of the environmental perturbations associated to climate change.

We performed a joint multidisciplinary approach, declined in: 1) a characterization phase aiming to identify the forcing parameters and their interactions, such as climatic, tectonic and volcanic stresses, on the facies and architecture of the lacustrine sedimentary system through times; 2) a thorough study of facies attributes, and more specifically early diagenesis processes that opened a new window to the understanding of the local effects of the major paleoenvironnemental changes; 3) a review and a discussion of the previously published geodynamical and climatic models to set our observations in the regional context.

The sedimentary succession (Tortonian to Messinian in age) has been extensively studied by paleontologists as they hosted many mammal remains. These paleontological studies, coupled with magnetostratigraphic and palynologic studies provide an insightful (even if incomplete) stratigraphic database. Our detailed faciological analysis (10 logged sections, 100 thin sections) and sequence stratigraphic interpretation highlighted the temporal evolution of the basin, with different sedimentation types: palustrine, deep lacustrine (varve-like), fluvio-lacustrine and finally tufa lake. Coupled diagenetic and geochemical analyses will also be presented and used as potential "proxies" to characterize the nature of lacustrine waters (salinity, alkalinity...). Finally, an integration of these local / punctual observations in the broad geodynamical context of the Eastern Aegean region is proposed. The outputs of these studies will also come out on the building of a well-documented database which could be used in a modeling phase with the stratigraphic modeling tool DIONISOS.

CHARACTERIZATION AND DISTRIBUTION OF THE MICROBIALITES WITHIN LACUSTRINE SERIES: THE EXAMPLE OF THE MAASTRICHTIAN-DANIAN YACORAITE FM, SALTA BASIN, ARGENTINA

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The classification of microbialites and their morphotypes, as well as the controlling factors upon their distribution and morphologies have received considerable attention for the last decade, but these issues are still a matter of debate. Some authors suggest that depositional environments, type of microbial communities or both biological and environmental processes may influence the development and distribution of these peculiar carbonates.

The latter are common in both modern and fossil lacustrine records. In such examples, the microbial build-ups have been usually described in details though their relationships with coeval lacustrine deposits have received little attention. For example, the stratigraphic distribution (preferential occurrences in peculiar system tracts...), lateral repartition (preferential association with specific depositional environments...) and the relative contribution of the various processes controlling their development are still obscure.

The present study is focused on the Yacoraite Fm, a mixed carbonate-siliciclastic series, that has been deposited during the sag phase of the Salta rift system (Maastrichtian-Danian), NW Argentina. Indeed, the Yacoraite Fm shows a large diversity of microbialite facies that exhibits various sizes, macroscopic morphologies and microscopic textures. The objectives of this communication are:

- to propose a typology of microbial facies occurring in the Yacoraite Fm;
- to constrain their lateral / stratigraphic distribution, by statistical analysis, in order to unravel their evolution in time and space;
- to propose some first thoughts on the factors controlling occurrences and distribution of such peculiar facies.

The macroscopic and microscopic analyses of the microbialites have led to the distinction of six different morphotypes: agglutinating domal stromatolites, planar mats, fine-grained stromatolites (isolated domes, laterally linked domes, columnar or branching), thrombolites, composite build-ups, and oncoidal facies.

The statistical analysis led on this series has enabled us to propose a stratigraphic, lateral and paleogeographic quantitative distribution of the microbialite macroforms. Some hypothesis on the controlling factors on the distribution of such peculiar facies have been proposed. Our observations suggest that macroscale growth morphologies of microbialites are primarily controlled by a complex interplay of external controls (climate, bathymetry, rate of siliciclastic input) and internal controls (water chemistry, hydrodynamics, turbidity and luminosity...).

CARBONATE PLATFORM RESPONSE TO THE TOARCIAN OCEANIC ANOXIC EVENT IN THE TIBETAN HIMALAYA: IMPLICATIONS FOR ENVIRONMENTAL CHANGE AND BIOTIC PLATFORM DEMISE

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The Toarcian Oceanic Anoxic Event (T-OAE, ~183 Ma) was a profound short-term environmental and climatic perturbation associated with the rapid release of 13C-depleted carbon into the ocean-atmosphere system, resulting in a significant negative carbon-isotope excursion (CIE). However, the general lack of characteristic T-OAE records outside the northern hemisphere has led to uncertainties in its spatial and temporal extent. In addition, many biotic carbonate platforms of the western Tethys drowned or shifted to chemical platforms coincident with the onset of the T-OAE, but the factors triggering biotic platform demise are still controversial and need to be better constrained. Here we present high-resolution microfacies analysis, geochemical (carbon isotope, total organic carbon, and manganese content) and sedimentological data of two Toarcian sections from a shallow-water carbonate platform, exposed in southern Tibet, paleogeographically located on the open southeastern tropical Tethyan margin of the southern hemisphere. The T-OAE in southern Tibet is marked by an abrupt major transgression and platform demise by changing form high-energy platform with rich benthic faunas to low-energy ramp characterized by frequent storm layers. This sudden change coincides with theToarcian negative carbon-isotope excursion (CIE), with high-frequency oscillations and steps within the overall shift to lower carbon-isotope values. Our new data confirm that the T-OAE profoundly influenced the climate and environment of the southern hemisphere, and suggest that the T-OAE carbon cycle perturbation was a result of rapid, massive and likely pulsed ^{13}C-depleted carbon injection into global ocean-atmosphere reservoirs. The Toarcian CIE also coincides with the occurrence of dark grey thinbedded mudstones, an absence of diverse benthos and of bioturbation, and TOC and manganese enrichment. These observations suggest oxygen-depleted conditions across the Toarcian CIE interval. Moreover, an increase in the frequency and intensity of storm deposits during the OAE interval is observed, emphasizing a close link between carbon-forced warming and tropical cyclones. Taken together, the environmental deterioration associated with the T-OAE likely led to the sudden biotic carbonate-platform demise by downing or a change to unfossiliferous oolitic platforms along the whole tropical/subtropical Tethys.

ARE ANDEAN ALLUVIAL FANS SENSITIVE TO FORCING?

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The stratigraphic record is our principle archive of landscape evolution on Earth, therefore understanding the limitations for its interpretation is a first order problem. Stratigraphic grain size trends in fluvial deposits encapsulate time-averaged stream processes and are often utilised as an environmental indicator for a discharge regime and sediment supply. However, observations of modern fluvial systems highlight a range of dynamic behaviours that could impact grain size trends and buffer signals of environmental forcing. For example, in transport limited rivers, it is not unusual for sediment to be removed and reworked from older surfaces when the local transport capacity of the river is in excess. The extent to which older deposits influence the size distributions of younger systems is not well understood. Furthermore, as fluvial systems increase in size, tributaries become important as lateral point sources for supplying sediment with potentially different sized loads.

Numerical modelling of sediment routeing systems, that diffuse material from a single point source to a sink, demonstrate the rate at which fluvial deposits fine downstream is predictable knowing the volume and calibre of the sediment supply, the spatial distribution of basin subsidence and the mobility of the substrate. In the absence of quantitative field data, it is unknown whether these simple 2D models are truly representative of the complex natural systems they aim to describe. If we want to be able to invert grain size trends for environmental boundary conditions, their sensitivity to lateral inputs of sediment needs to be quantified.

Using the Iglesia basin of the South Central Argentine Andes as a natural laboratory, we test if modern grain size fining trends on three adjacent fans can be predicted using a self-similar numerical model. Each fan is large (> 25 km in length) and fed by ephemeral streams draining the Argentine Frontal Cordillera of the High Andes. We quantify the size distribution of the sediment supplied to each fan, from measurements in the field, and estimate the sediment flux using a global regression model, BQART, informed by precipitation and temperature data from global climate models. The distribution of subsidence beneath each fan is well constrained by basin-wide seismic survey data and dated basin fill outcrops. Informed by these parameters, we analyse the extent to which observed grain size trends translate the modern boundary conditions. We then adapt the model to include lateral inputs of sediment to each alluvial fan system and analyse the extent to which these inputs buffer the sensitivity of the system to environmental forcing. As large bajada fan systems are most representative of what is preserved in the ancient stratigraphic record, our findings have significant implications for our ability to sensitively invert ancient fluvial stratigraphy for environmental forcing.

PREDICTING SHALE RESERVOIR PROPERTIES FROM FACIES AND MINERALOGY: AN EXAMPLE FROM THE DEVONIAN MUDSTONES IN WESTERN CANADA

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Upper Devonian shale formations in western Canada are important targets for oil and gas exploration and development, including the Horn River Group in the Horn River Basin, northestern British Columbia, and the Duvernay Formation, Alberta. Numerous long cores from both units and additional wells with electric logs, have enabled us to develop detailed depositional and sequence stratigraphic models. We relate depositional facies and stratigraphic sequences to rock composition, from which we have deduced key paleoenvironmental parameters including redox condition and biogenic production. Finally, we examine the relationship of facies and rock composition to petrophysical and geomechanical properties.

The Late Devonian paleogeography in western Canada was dominated by carbonate platforms, isolated reefs and intervening black shale basins. Depositional facies in both the Duvernay and Horn River shales include both anoxic and dysoxic to oxic assemblages associations, recognized by the presence or absence of bioturbation, benthic body fossils and trace element geochemistry. Anoxic facies are most enriched in organic carbon and are dominated by biogenic silica or carbonate minerals; sedimentary fabrics are consistent with little to no bioturbation, and much of the sediment was deposited through suspension settling. Dysoxic to oxic facies generally contain lesser but nonetheless significant amounts of organic carbon; these may also be carbonate-or silica-rich but typically contain more clay and are characterized abundant evidence of bioturbation; and sediment was deposited through a variety of processes, including sediment gravity flows and contour currents. Transitional facies are locally present. Facies assemblages are related to both geographic position and stratigraphic sequence systems tracts. In general, anoxic facies become increasingly common in distal parts of the basin, whereas dysoxic to oxic facies are more common in settings near basin margins. Similarly anoxic facies are more widespread in transgressive systems tracts, whereas dysoxic oxic to facies are more widespread in lowstand and falling-stage systems tracts. Sea level cycles are present at multiple orders.

Geomechanical properties, specifically brittleness and hardness, are strongly related to clay content; increasing clay content results in a more ductile formation, whereas carbonate and biogenic silica produce a harder formation. Significantly, detrital quartz has little effect on hardness. Because rock composition is controlled by paleogeography and sequence stratigraphy, geomechanical properties can be spatially and stratigraphically predicted.

Petrophysical properties are less strongly related to rock composition. Several modes of porosity are evident: secondary porosity in organic matter; secondary porosity in minerals, especially carbonates; primary (?) interparticle porosity, especially between clay minerals, and different porosity types dominate at different thermal maturities. The presence of multiple types of porosity results less systematic or simple controls on total porosity. Pore sizes and pore throat sizes are related to total organic carbon, with smaller pore throats in high TOC samples in gas window samples; this is a function of the inherently smaller size of pores in organic matter. Matrix permeabilities are positively correlated to permeability, but permeability at a given porosity varies as a function of thermal maturity.

PALAEOENVIRONMENT AND POSITION OF THE PRECAMBRIAN–CAMBRIAN BOUNDARY WITHIN THE VANRHYNSDORP GROUP OF SOUTH AFRICA: SEDIMENTARY FACIES ANALYSIS AND DETRITAL ZIRCON GEOCHRONOLOGY

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The Vanrhynsdorp Group is a mainly fluvio-marine siliciclastic succession with minor carbonates that outcrops in the northwestern part of the Republic of South Africa. The critical Precambrian-Cambrian boundary falls within the lower part of the group but its nature, exact stratigraphic position and depositional environments remain unresolved. The group was deposited in the Vanrhynsdorp Basin, which is the southernmost extension of the Nama Foreland Basin. Consequently, the Vanrhynsdorp Group has been correlated with the world-famous Nama Group, which features a unique assemblage of Ediacaran-Cambrian body and trace fossils. Precise correlation of siliclastic and carbonate units with those of the Nama Group remains uncertain. No body fossils have been discovered in the Vanrhynsdorp Group; however, typical Early Cambrian ichnoassemblages, including treptichnids and Oldhamia, occur within middle and upper parts of the Vanrhynsdorp succession.

Using U-Pb dating of detrital zircons by LA-ICP-MS, we have recently obtained radiometric ages for the middle part of the Vanrhynsdorp Group (Besonderheid Formation). The radiometric data, yielding a maximum depositional age of 524 to 528 Ma from the youngest zircon grain population, indicate that the Precambrian-Cambrian boundary is stratigraphically lower down in the succession than previously thought. This result also corroborates trace fossil evidence, which suggests that the lowermost units are Late Ediacaran while the bulk of the upper units are Early Cambrian. To further constrain the age of the lower Vanrhynsdorp Group, and pinpoint the position of the Precambrian-Cambrian boundary, we have processed six samples for detrital zircon extraction and age determination from the lower units of the succession. In addition, we have used sedimentary facies analysis to track lateral and vertical facies variation within the lower part of the Group and refine its palaeoenvironmental setting.

Our preliminary results suggest a dominantly shallow marine, partly storm-dominated depositional environment for the lowermost units as opposed to the previous interpretations of dominantly alluvial settings. By integrating our sedimentological and geochronological results, we hope to achieve an improved understanding of the depositional history of the Vanrhynsdorp Group during the critical Ediacaran-Cambrian transition.

VARIABLE RHEOLOGY IN SEDIMENT GRAVITY FLOWS FROM MIXED CLASTIC-CARBONATE SYSTEMS – THE CALP OF THE DUBLIN BASIN, IRELAND

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Sediment gravity flows tend to undergo flow transformations as they run out. Slope failures may progressively break up to create debris flows that then transform to form largely turbulent flows. The reverse transformation also occurs, with turbulent flows undergoing turbulence damping to become transitional or laminar. Loss of turbulence can be triggered by flow deceleration and/or clay particle interactions in sections of the flow where clays and other components are hydraulically concentrated and interact to increase cohesivity. In addition, where flows delaminate their substrate, shearing, clastcharged near-bed layers may form. Hybrid event beds are a product of these sorts of transformations of turbulent flows and ideally comprise a basal sandy division emplaced by the turbulent frontal part of the flow, and increasingly muddy sandstones reflecting deposition from trailing turbulence damped sectors. To date much of our understanding of hybrid events beds comes from siliciclastic systems where partitioning of the flow into sectors with different rheology is often accompanied by strong fractionation of clay chips, mica flakes and carbonaceous fragments prior to flow arrest. Less is known about carbonate systems although there is increasing interest in off-platform transport to deep-water and the character and deposits of sediment gravity flows bearing diverse carbonate particles and abundant organic matter. The focus here is on mixed clastic-carbonate systems where the variable grain components may also be fractionated and force flow transformations. The Carboniferous Dublin Basin formed as a consequence of a short-lived phase of extension in the early Viséan which created a deep-water basin floor flanked by normal fault scarps and unstable slopes. Carbonate sediment gravity flows were sourced from coeval shallow water platforms and shorelines and range from Chadian to Brigantianin age. They form a succession over 2 km thick that is colloquially referred to as the 'Calp'. Calp sediment gravity flow deposits are well exposed on the coast north of Dublin and have been extensively cored in engineering projects beneath the city of Dublin and around sites of Zn-Pb mineralisation. The deposits cannot be understood using conventional facies models for calciturbidites in that many are associated with thick muddy caps that include significant silicate clay in addition to carbonate. The event beds show evidence for analogous flow transformations to those seen in clastic systems with well-graded basal grainstones overlain by sharp transitions into overlying finegrained capping divisions that include common banding (alternations of dark muddy layers and cleaner calcareous divisions with loaded bases). The basal grainstones can show cross-bedding and preserve dune forms. This implies strong lateral longitudinal variations in flow rheology with the front of the flow largely bypassing before the rear decelerated and became transitional in character. Common banding in these deposits may reflect an abundance of microbial coatings and particulate organic matter and the well represented banded divisions and mudstone caps may represent a significant sink for offplatform Carbon burial.

PALAEOENVIRONMENTAL CHANGE IN THE HETTANGIAN TO TOARCIAN CONTINENTAL KAROO STRATA IN MOYENI, QUTHING DISTRICT, SOUTHWESTERN LESOTHO

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The Stormberg Group in the main Karoo Basin of southern Africa encompasses the geological history of the Late Triassic-Early Jurassic in southernmost Gondwana and is associated with at least one major global mass extinction event. The depositional environment is known to have shifted from a semi-arid fluvio-lacustrine to an aeolian system before the outpouring of the Lower Toarcian continental flood basalts of the Drakensberg Group (Karoo-Ferrar Large Igneous Province). Pillow lavas and sedimentary interbeds with ephemeral stream and lake affinities are common in the lower Drakensberg Group both in Lesotho and South Africa. The study area in Moyeni (SW Lesotho) exposes Lower Jurassic sedimentary rocks of the upper Elliot and Clarens formations (Stormberg Group) as well as the lowermost Drakensberg Group. Integrated geological methods (e.g., field mapping, sedimentary facies and ichnofacies analysis, petrographic studies) were used for a high resolution documentation of the palaeoenvironmental changes in the Moyeni area during the Early Jurassic.

In Moyeni, the Elliot Formation is a succession of very fine to fine-grained sandstone (eithermassive or with ripple cross-lamination, low-angle cross bedding) and sandy siltstone with in situ carbonate nodules, various bone fossils and ichnofossils (ranging from adhesive meniscate burrows to large theropod dinosaur footprints) as well as frequent desiccation cracks. Moyeni boasts two major ichnosites within the Elliot Formation: a) The lower ichnosite, at ~1500 m altitude, is within a medium to thinly bedded sandstone succession that is sandwiched between floodplain mudstones with well-developed desiccation cracks that are up to 20 cm wide and > 150 cm deep. The ichnosite is well-known locally for > 60 years and preserves > 450 tracks of theropods, quadrupedal ornithischians, amphibians (temnospondyls) and crocodilomorphs. b) The upper ichnosite, at ~1565 m altitude, is newly discovered and preserves large *Eubrontes* isp. ichnites. It is found at the top of a 14 m thick, medium-grained sandstone package, which thins and fines upward into a ripple marked surface. The Clarens Formation is dominated by very thick, tabular, fine to medium-grained, massive to large-scale cross-bedded arenites, however in its lowermost parts, channel-and wedge-shaped, massive sandstones and rare, thin-bedded mudstones are also present. Within the lowermost Drakensberg Group, interbedded with lava flows and pillow lavas, sandstone units (< 10 m thick) are common. These massive to crossstratified sandstone beds typically thin and fine upward, and at least locally, terminate in surfaces that are covered by symmetrical ripple marks.

Sedimentological evidence indicates that during the deposition of the Elliot Formation, Moyeni was part of a low energy fluvial system, prone to flash flooding and with overbank areas dotted by shallow lakes. During the deposition of the Clarens Formation, the environment was initially seasonally wet and thus allowed the preservation of fluvio-lacustrine sediments, however overtime aridification gave rise to an aeolian system that was dominated by eastward migrating, large sand dunes. Finally, by the early stages of the Toarcian Karoo volcanism, the climate became again semi-arid and seasonally wet, the land surface was partially covered by lakes, and the outpouring of the lavas was intermittently interrupted by fluvio-lacustrine sedimentation.

FROM BASIN-SCALE EXPLORATION TO FIELD-SCALE PRODUCTION: AN INNOVATIVE FORWARD STRATIGRAPHIC MODELLING APPROACH COUPLED WITH RESPONSE SURFACE METHODOLOGY

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With the large amount of multi-disciplinary and multi-scale datasets gathered along the past years by the Oil and Gas community, geoscientists face many challenges while trying to solve complex problems related to the E&P chain. Three of the main ones are (1) the integration of such important amounts of data, (2) difficulties in managing scaling while moving from large basin scale exploration to restricted field scale production and finally (3) ways of de-risking the petroleum systems elements through innovative approaches in order to localize leads, characterize reservoirs and later enhance production. In this communication we explore the forward stratigraphic modelling advances used to integrate wide multi-disciplinary and multiscale datasets along source to sink profiles.

Dionisos Flow forward stratigraphic model is a deterministic process based tool that allows reproducing the interaction between subsidence, eustatic variations and the sediment routing systems that represent the integrated behavior of “source to sink” geomorphologic processes comprising sediment erosion, transport and deposition from catchment areas towards the shelf, slope and basin floor. The use of geomorphological, geological and geophysical multi-scale constraints in Forward Stratigraphic Models has shed light on the various interactions between the local, regional and global scale driving mechanisms (e.g. tectonic versus thermal subsidence rates, accommodation, climate evolution, drainage systems activation, eustatic variations amongst others) that influence sediment transport and deposition along evolving landscapes.

The need for more efficient and faster ways of assessing the sensitivity of stratigraphic models with regards to all these driving mechanisms lead to the development of an integrated workflow applicable at basin and reservoir scale. The coupling of Dionisos Flow with CougarFlow offshore Novascotia, the Gulf of Mexico and Trinidad allowed the generation of automated multi-realizations using a Latin hypercube experimental design to measure the impact of varying uncertain environmental parameters on the referencecase geological model. The use of response surface methodologies permits a more robust sensitivity analysis assessment of environmental parameters on sediment texture/facies and thicknesses.

The coupling of multi-scale stratigraphic models with response surface methodolologies and multirealization opens new opportunities to predict the lateral and vertical extent of sedimentary facies and thus de-risk petroleum systems elements of various geological systems at a global scale from an exploration to production perspective.

SOFT SEDIMENT DEFORMATION STRUCTURE CHARACTERISTICS AND FORMATION MECHANISM DISCUSSION OF THE UPPER TRIASSIC CHANG 7 MEMBER IN LONGDONG AREA, THE ORDOS BASIN, CENTRAL CHINA

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Soft sediment deformation structures are regarded as typical geological records preserved in strata. Their main classification, basic characteristics, triggering mechanisms and formation mechanisms have been a hot and difficult issue both at home and abroad. According to detailed observation and description of 344 m cores in 27 typical wells, the soft sediment deformation structures are characterized by various types, multiscale, multi-cause and wide distribution, which are widely developed in Triassic Chang 7 Member, Longdong area, the Southwest Ordos Basin. Based on morphological characteristics and formation mechanisms, the soft sediment deformation structures are divided into three categories: soft sediment lateral disturbance deformation, soft sediment vertical load deformation and soft sediment non-directional invasion deformation. These soft deformation structures are mainly composed of liquefied oscillating deformation, liquefied curled deformation, liquefied cross-bedding, mudstone tear crumbs, high-groove structure, micro fold, load structure, groove mark and flute casts, liquefied sandstone veins, drainage structure, beaded structure and locally visible micro-fault.

Soft sediment deformation structures are widely developed in Chang 7 Member, most of which were concentrated more in the Chang 72 sub-member and less in the Chang 73 sub-member, with distinct representative type. Spatially, they are mainly distributed in the half-deep lake-deep lake area in the central and eastern study area, presenting the increasing trend from southwest to northeast and are mostly developed in Zhenyuan.

According to special sedimentary analysis from different types of soft sediment deformation structures, the structures are characterized by various driving factors and complex deformation mechanisms. The causes are disturbance liquefaction, sedimentary load compaction, sliding, slumping, earthquakes and volcanic activities. The first two causes are more common; their deformation mechanisms are mainly visco-plastic deformation and intergranular shear.

As the exploration in the research area increases, the potential relationship between soft sediment deformation structures and the formation, development and accumulation of high quality hydrocarbon source rocks during the same period will be another important field of study.

RESPONSE OF MID-LATITUDE VEGETATION TO CLIMATIC PERTURBATIONS DURING OAE2

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The Cenomanian-Turonian boundary witnessed prominent perturbations in global biogeochemical cycling, oceanography and climate expressed in the widespread deposition of organic-rich marine shales (OAE2) and a pronounced positive carbon isotope excursion (CIE). Despite the global significance of this event, information on the dynamics of continental ecosystems during OAE2 is still lacking. Given the outstanding warm sea-surface temperatures (SSTs) reconstructed from proxy data for the OAE2 interval, the composition of terrestrial biomes must have responded to the inferred climatic changes. Here we present palynological and organic-geochemical data from a stratigraphically well-constrained marine succession from the Southern Provence Basin (SPB) located in the western Tethys domain. New biostratigraphic results (calcareous nannofossils, planktonic foraminifera) coupled with carbon isotope stratigraphy show that the interval corresponding to the OAE2 and associated CIE is represented by a ~150 m thick section composed of marls with few limestone intercalations. TEX86 data indicate very warm SSTsof up to33°C, which is in line with previous mid-latitude temperature records. An interval with lower TEX86-derived temperature estimates is paralleled by a trough-shaped decline in carbon-isotope values and tentatively correlated with the so-called Plenus Cold Event, a phase of distinct cooling in the early phase of OAE2. The spore-pollen assemblage is dominated by non-saccate gymnosperm (Inaperturopollenites, Araucariacites, Classopollis) and angiosperm pollen (mainly representatives of the Normapolles group incl. Atlantopollis and Complexiopollis), with pteridophyte spores being diverse but quantitatively less important. Up-section, the spore-pollen assemblage shows distinct changes in frequency distribution patterns including a pronounced increase in Inaperturopollenites and Classopollis. In contrast, the interval assigned to the Plenus Cold Event is characterized by a distinct rise in the angiosperm pollen Atlantopollis microreticulatus, reaching up to 16.4 % of the total palynoflora. In summary, the integrated palynological and geochemical dataset from the SPB documents the dynamics of mid-latitude vegetation during a phase of outstanding global warmth during OAE2. Despite the exceptional temperatures, a diverse and rich flora occupied various habitats in the hinterland of the SPB. Fluctuations in spore-pollen frequency distribution are considered to reflect significant climatic changes in the course of OAE2 controlled ultimately by the interplay of large-scale magmatic activity and enhanced organic carbon burial.

ASSESMENT OF DURATION OF BASIN FILLING WITHOUT CHRONOSTRATIGRAPHIC DATA: A CASE STUDY FROM THE CENOZOIC FORELAND BASIN OF SPITSBERGEN

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The kilometer-scale thick progradational succession containing the Gilsonryggen Member of the Frysjaodden Formation (offshore), the Battfjellet Formation (shallow marine) and Aspelintoppen Formation (continental) was the main sedimentary response to the Paleogene uplift of the West Spitsbergen Fold-andThrust Belt (WSFTB) of Svalbard, Norway. The excellent exposures both on close-up facies-scale and on kilometer seismic-scale illustrates aspects related to the link between coastal sedimentation and basin floor mass-gravity deposition, the process understanding of clinoform deposition, the spatial-temporal structure of continental to submarine systems tracts, the coupling of seismic scale geometries to outcrops and subsurface studies, and to foreland basin sedimentation in general.

Constraints on the timing of both structuring and the coupled foreland basin sedimentation is limited in this system. Only a few datings within the basin fill have been published; one gives an upper Paleocene age based on dinoflagellates within the lowermost part of the Frysjaodden Formation; another is dated to ca. 56 Ma at the level of the PETM (Paleocene-Eocene thermal maximum) close to the base of the Gilsonryggen Member using radiometric dating of bentonites and astrochronology.

Here we carry out a source to sink assessment of the linked WFTB and CB foreland basin fill with particular focus on filling times of the marine succession from the base of basin floor fans and upwards to the first non-marine sediments. One way to circumvent the lack of reliable datings is to use both source-derived modern-day sediment production models and sink-derived progradational rates from modern systems, two partly independent approaches to arrive at first order estimations of filling times. The first approach estimates river mouth suspended loads applying the catchment sediment production model BQART of Syvitski and Milliman, 2007, the second method applies empirical data from progradation rates from modern deltas that have catchment, climatic and geometric properties consistent with what can be inferred from the Svalbard source-to-Sink system.

LATE OLIGOCENE–EARLY MIOCENE HUMIDITY CHANGE RECORDED IN TERRESTRIAL SEQUENCES IN THE ILI BASIN (SOUTH-EASTERN KAZAKHSTAN, CENTRAL ASIA)

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Today, Central Asia is the largest arid zone in the mid-latitudes of the Northern Hemisphere, with climates characterised by a strong seasonality in precipitation, relatively wet winters and dry summers. The combined effects of orogenic surface uplift, Paratethys retreat, changes in atmospheric moisture transport and global cooling enhanced aridification of Central Asia, driving one of the most prominent Cenozoic climate change events of the Northern Hemisphere. Deciphering regional longterm patterns of Central Asian hydrology is, therefore, a key element in understanding the role of Northern Hemisphere mid-latitude drying in the global hydrological system. Whilst records of aeolian dust deposition in the Junggar and Tarim basins suggest desert-like environments in inland basins, palynological and carbonate stable-isotope evidence from the north and central Tien Shan indicate wetter conditions likely due to orographically enhanced precipitation. Sedimentary basins in Central Asia allow the detailed reconstruction of regional climate histories during the Cenozoic. One of those sedimentary basins, the Ili Basin in the Northern Tien Shan Mountains, accommodates several hundred meters of exposed Cenozoic strata with well-developed paleosols. Paleosols archive variability in soil temperatures, soil pCO_2 and weathering rates that are sensitive to changes in vegetation, rainfall and temperature on seasonal and longer timescales. This study presents palaeo-hydrological data derived from calcrete-bearing palaeosol horizons in a 160-m-thick Oligocene–Miocene valley in the northern Ili Basin, south-eastern Kazakhstan. We characterize long-term palaeoenvironmental conditions between the late Oligocene and early Miocene in south-eastern Kazakhstan based on stable isotopes, elemental geochemistry and laser ablation U-Pb geochronology from alluvial, fluvial and pedogenic deposits.

Sedimentary facies and geochemical weathering indices suggest an increased surface and groundwater discharge fed by orographically enhanced precipitation in the Tien Shan hinterland. In contrast, pedogenic stable isotope data and elevated rates of magnesium fixation in clay minerals mirror enhanced rates of evaporation in the vadose zone due to protracted aridification. We suggest that pronounced surface uplift of the Tien Shan Mountains during the Oligocene–Miocene transition promoted regionally increased orographic precipitation and the development of fluvial discharge systems. The results provide new insights into Central Asian climate dynamics during a critical interval of Northern Hemisphere Cenozoic climate evolution.

PALEOGEOGRAPHIC RECONSTRUCTIONS OF RIVER SYSTEMS DURING THE EARLY CORINTH RIFT EVOLUTION (GREECE)

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Syn-rift fluvial successions record the evolution of drainage systems in response to normal fault growth and migration of fault activity. Antecedent drainage can persist or can be replaced by consequent drainage. Both consequent and antecedent rivers can coexist and thus provide different sediments entry points to the basin. Depending on the balance between accommodation creation and sediment supply in the alluvial basin, sediments can be by-passed, temporarily stored or preserved in the stratigraphic record.

This study focuses on stratigraphic record of river systems during the evolution of the southern margin of the Plio-Quaternary Corinth rift (Greece). In the western and central rift, sediments are preserved in a series of uplifted normal fault blocks. Detailed mapping and logging of stratigraphic units are coupled with magnetostratigraphy and biostratigraphic markers to date and correlate the alluvial succession across and between fault blocks. By integrating new work in the western rift and published work, we present a coherent stratigraphy and original paleogeographic maps of the Corinth rift.

Throughout rift evolution, we identify several major long-lived sediment routing systems that supplied coarse sediments into the basin. Paleogeographic reconstruction of the early rift phase shows that two major routing systems (Kalavryta and Killini) coexisted and flowed N–NE to E across active E–W-striking subsiding fault blocks.

The Kalavryta river system represents the largest antecedent drainage system captured by the westward migrating rift. Deposits evolved downstream from coarse fluvial conglomerates to deltaic and lacustrine deposits. Rivers terminated eastward where small deltas are built into a shallow lake that occupied the central Corinth rift. This through-going river system evolved over about 2 Myrs and developed over a distance of about 30 km above active faults. Sediment supply was relatively high and largely outstripped the creation of accommodation. This river system was then reorganised by later northward migration of fault activity. During this time, the Killini River system in the central rift built fan deltas during hangingwall fault migration over 3 Myrs. As faults migrated northward, progressive basin deepening is also recorded. In the northern rift margin, the Rodini river system interacted with a footwall migrating fault system. The river abandoned its older deposits to build a new fluvial system in the footwall of the abandoned fault. The fluvial system developed over a distance of about 20 km since the last 1.8 Ma.

These river systems show that sediment supply was mainly from the west throughout rift evolution. They formed large axial drainage infilling the lacustrine basin in the eastern rift, and thus recording diachronous basin deepening. The persistence and stability of river systems are significantly controls facies distribution and stratigraphic architecture. However, these river systems were reorganised due to migration of fault activity and associated fault linkage and increasing extension rate from about 1.8 Ma. Our understanding in the sediment routing systems in the Corinth rift is limited by the lack of data to correlate proximal fluvio-deltaic system with basinal turbidites. This can be improved by further study in the eastern rift and the offshore Gulf.

INTERACTIONS BETWEEN ANTECEDENT DRAINAGE AND EARLY RIFTING: A CASE STUDY FROM THE PLIO-PLEISTOCENE CORINTH RIFT, GREECE

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Continental 'overfilled' conditions during rift initiation are conventionally explained as due to low creation of accommodation compared with sediment supply. Alternatively, sediment supply can be relatively high from the onset of rifting due to an antecedent drainage system. The alluvial Lower Group of the western Plio-Pleistocene Corinth rift is used to investigate the interaction of fluvial sedimentation with early rifting. This rift was obliquely superimposed on the Hellenide mountain belt from which it inherited a significant palaeorelief. Detailed sedimentary logging and mapping of the well-exposed syn-rift succession document the facies distributions, palaeocurrents and stratigraphic architecture. Magnetostratigraphy and biostratigraphy are used to date and correlate the alluvial succession across and between fault blocks. For about 2 Ma, a transverse low sinuosity braided river system flowed N–NE to E across E–W-striking growing fault blocks (4 to 7 km in width). Deposits evolved downstream from coarse alluvial conglomerates to fine-grained lacustrine deposits over 15 to 30 km. The length scale of facies belts is much greater than, and thus not directly controlled by, the width of the fault blocks. At its termination, the distributive river system built small, stacked deltas into a shallow lake. The presence of a major antecedent drainage system is supported by: (i) a single major sediment entry point; (ii) persistence of a main channel belt axis; (iii) downstream fining at the scale of the rift basin. The zones of maximum subsidence on individual faults are aligned with the persistent fluvial axis, suggesting that sediment supply influenced normal fault growth. Instead of low accommodation rate during the early rift phase, this study demonstrates that facies progradation can be controlled by continuous and high sediment supply from antecedent rivers.

SEQUENCE STRATIGRAPHY OF A COMPLEX FORELAND BASIN – A TOOL TO UNDERSTAND FACIES DEVELOPMENTS AND BASIN-PLATFORM CORRELATIONS BEYOND THE LIMITS OF BIOSTRATIGRAPHY (RHENISH KULM BASIN, MISSISSIPPIAN, GERMANY)

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A plethora of sequence stratigraphic studies is devoted to shallow-marine platform settings. In contrary, approaches to basinal settings are scarce. They are mostly confined to siliciclastic turbidite fan systems. Studies of complex deeper-water foreland basins with differentiated lithosomes are still missing. Using the Lower Carboniferous (Mississippian) Rhenish Kulm Basin (RKB) in Germany as an example, sequence stratigraphic principles and problems of such settings are elucidated. The RKB is one of the typical asymmetrical deeper-water foreland basins developing in front of the Variscan Orogen. Three megafacies interfinger and might overwhelm the adjacent one in time during progradation of the orogen. These are (1) proximal (internal) siliciclastic flysch facies, (2) central starved basin facies, (3) calciturbidite facies. Calciturbidites are derived from the external NW European shallow-water carbonate platform, or from not preserved intrabasinal sources. Besides, [4] deep intrabasinal swell facies is characterized by condensed successions. Differentiation of sequence tracts depends mostly on gravitative reworked sediment types which are related to the complex basin topography. On the basin plain, sequence tracts/sequences might be masked and amalgamated. LSTs are characterized by erosional unconformities at the basin margins and on highly elevated intrabasinal highs. At the slopes coarse-grained resediments occur, e.g. debrisflow sediments or conglomerates. In some sequences, the LST is not recognized. TSTs are often characterized by black shales that spread throughout the basin and homogenize facies differences. Outside the internal flysch facies, HSTs consist of well-developed calciturbidite successions, but within the flysch facies by greywacke-poor, mud-rich successions. On the top of deeper water swells condensed micritic limestones were formed; calciturbidites might occur at their flanks. Maximum flooding intervals (*mfis*) are rarely recognized. A spectacular case is the basin-wide deposition of a microbe-cephalopod limestone. Sequence boundaries are mostly recognized by sharp-cut facies boundaries; unconformities are rare due to the exaggerated water-depth. In cases, sequence stratigraphic interpretation is strengthened by biotic response. Sequence boundaries might be enhanced by faunal breaks. Plant fragments are preferentially associated with TSTs. Diversity peaks occur during HSTs. Both recognized *Mfis* are connected with bioevents (ecological epibole, maximum completeness epibole). Backed up by biostratigraphy, 13 third order sequences are recognized in the RKB between latest Devonian and latest Mississippian. The lower nine sequences are correlated with the sequences of the Belgium shallow-water carbonate platform and further Palaeotethyan platforms. Moreover, two latest Viséan (Brigantian) sequences, and, in spite of the prograding Variscan Orogen, regionally two lowermost Namurian (Serpukhovian) sequences are discerned. The results prove that the lithostratigraphic successions in the foreland basin are not random, but controlled by extrinsic sea level variations. These more rapid variations overrule the gradual tectonic development of the RKB, i.e. origin, migration and demise of the megafacies realms. Results also indicate the Palaeotethyan, if not global isochroneity of Mississippian sequences. The application of diagnostic lithofacies to decipher sequences in the RKB might be transferred to other European and North African Kulm basins. First comparisons with successions in the Sudetes, Moravia, and the Montagne Noire are promising, but have to be detailed.

DIVERSIFIED INTERNAL COMPOSITION OF DRUMLINS IN THE STARGARD DRUMLIN FIELD, NW POLAND AND ITS IMPLICATIONS FOR THE SUBGLACIAL PROCESSES

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Numerous studies have provided insight into processes operating under contemporary and palaeo ice sheets. Many of these studies concerned drumlins, landforms whose formation is essential to the understanding of subglacial soft-bedded systems. Despite the interdisciplinary efforts involving sophisticated analytical and interpretative tools the “drumlin problem” remains elusive and continues to generate much controversy.

In this study the geological composition and internal structure of several drumlins from the Stargard drumlin field (NW Poland) in the terminal area of a major last-glacial palaeo-ice stream was examined in excavated trenches and outcrops. In each trench, sediment description and fabric analyses were conducted, and samples collected for micromorphological, AMS (anisotropy of magnetic susceptibility) and grain size measurements.

Two compositional types of drumlins were identified in the Stargard drumlin field: (1) mainly till drumlins and (2) mainly sorted sediment drumlins. Type 1 drumlins are typically composed of macroscopically homogeneous till with minor, max. 5 cm thick sand stringers and sparse silty inclusions. Occasionally, the till contains thin, highly deformed layers with clay-and pebble-sized clasts at the top, and a continuous thin layer of clay. Till macro-fabric measurements reveal a high clustering strength and low isotropy index. Drumlins composed of sorted sediments reveal ductile deformations throughout the observed outcrops including diapirs and folds.

The internal composition of both drumlin types suggests high subglacial pore-water pressure in the sediments which contributed to the deformation. The overall observations of till drumlins point to a shallow subglacial deformation not affecting the entire till thickness at any time intervening with ice/bed separation facilitating enhanced basal sliding. The intra-till clay layer of low hydraulic conductivity contributed to elevated pore-water pressure in the sediment causing its fluidization and deformation. The intervening thinskinned sediment deformation and basal de-coupling resulted in fast ice flow that, coupled with material release from the ice sole and its accretion at the ice/bed interface facilitated drumlin build-up and shaping. A combination of ice stress and high pore-water pressure likely initiated moulding of the sorted sediments into bumps which in turn triggered further deformation. The final drumlin relief is attributed to shaping by subglacial meltwater erosion.

A CLASSIFICATION OF CLAY-RICH SUBAQUEOUS DENSITY FLOW STRUCTURES

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In this study the transformations of relatively high-density subaqueous clay-laden flows from proximal to distal regions are experimentally investigated. Based on the observations a classification is proposed according to the state of the free shear and boundary layers and existence of a plug layer. A connection between the emplaced deposit by the flow and the relevant flow type is drawn through the results obtained from the flume experiments. These were performed using 9%, 15%, and 21% sediment mixture concentrations composed of sand, silt, clay, and tap water, on varying bed slopes of 6°, 8°, and 9.5°, and with discharge rates of 10 m^3/h and 15 m^3/h. Stress-controlled rheometry was performed on the mixtures to obtain apparent viscosity data.

According to this classification, a cohesive flow may fall within one of five distinct flow types: 1) a plug flow (PF) with laminar free shear and boundary layers, 2) a top transitional plug flow (TTPF) containing a turbulent free shear layer, a plug layer, and a laminar boundary layer, 3) a complete transitional plug flow (CTPF), consisting of a turbulent free shear and boundary layers and a plug, 4) a transitional turbidity current (TTC), with a turbulent free shear layer and a laminar boundary layer, and, 5) a completely turbulent turbidity current (TC). Furthermore, it is proposed that a Froude number, two Reynolds numbers, and a dimensionless yield stress parameter are sufficient to associate a flow type with a natural large scale density flow.

During the experiments, flow type PF resulted in en masse deposition of a thick uniform ungraded muddy sand mixture, which was emplaced once the yield stress overcame the gravitational forces within the tail region of the flow. Flow type TTPF resulted in deposition of a thin ungraded basal clean sand layer during the run. This layer was covered by a muddy sand deposit from the tail. Flow type TTC did not deposit any sediment during the run. A uniform muddy sand mixture was emplaced by the tail of the flow. Flow type TC resulted in deposition of poorly sorted massive bottom sand layer. This layer was overlain by either a muddy sand mixture or a sand and silt planar lamination. Flow type CTPF was deduced from theory but was not observed during the experiments. Furthermore, it was observed that flows which are in transition from a TTC to a TTPF result in a thin bottom clean sand layer covered by a banded transitional interval. This was overlain by a muddy sand layer and a very thin clean sand layer, resulting from traction by dilute turbulent wake. In all cases a mud cap was emplaced on top of the deposit after the runs were terminated.

TRACE ELEMENT CHARACTERIZATION IN KARST AQUIFER SEDIMENTS OF THE YUCATAN PENINSULA SINKHOLES

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The presence and movement of trace elements in different environmental matrices has been described and investigated, due to human health and ecological risks. At the Southeastern part of Mexico, the groundwater is the main source for water supply. The sinkholes (ts'ono'ot in Mayan language) are commonly employed for diverse uses, and water quality remains the main threat. To determine if the sediments are acting as sinks or sources of trace elements in the groundwater is needed, in order to preserve the water quality and to guarantee the consumers' health in the hydrogeological reserve area of the sinkholes ring decreed in 2013 (the first hydrogeological reserve in Mexico; DOF, 2013). The "Ring of Sinkholes" is an alignment of sinkholes in the external ring of Chicxulub Crater at Yucatan State Mexico. The study highlights the concentration, behavior and controlling factors of trace element in sinkholes sediment from karst aquifer. This is the first study in the area with this approach. Sediment samples were collected in order to analyze trace elements content of the top and bottom of sinkhole collapse. The trace elements concentration order in sinkholes sediment samples is: Sr> Pb> Cu> Zn> Li> Cr> > Cd. The most significant relationships are between Sr and the other elements. Pb shows high concentrations in sediment samples from all sites (Teabo and Calcuch sinkholes mainly). Regarding the sequential extraction procedure, a potential order of importance of five fractions in sediments is: Residual> Organic matter> Carbonates> Exchangeable> Water-soluble, and confirms that sinkholes sediments are acting as a sink of trace elements, and no anthropogenic pressure exist in the groundwater of the hydrogeological reserve. The stability of trace elements in the sediments decrease in the order Cd> Pb> Zn> Cr> Cu> Sr. The controlling factors of the trace elements in sinkholes sediments are the oxidative conditions, the pH decrease and the ionic composition.

MULTI-DIRECTIONAL DEFORMATION DURING RIFT INITIATION: EXAMPLE OF THE TRIASSIC BASINS IN THE U. K.

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The Triassic formations exposed in the U.K. represent deposition within shallow-water lagoons and carbonate platforms that experienced variable, but very moderate detritus influx. Small basins existed at that time, their fill recording the first tectonics movements associated with Mesozoic rifting. This was followed in the Early Jurassic by the development of grabens that were bounded by major faults. Despite the absence of pronounced morphology on the sea floor at the time, internal deformation of the Triassic sediments that shortly followed deposition is observed at a regional scale; from southern England to Northern Ireland. Slumps, recumbent folds, injective bodies of sediment that cut upper layers, massive fluidized units, convolute bedding and faults have deformed many horizons of the Rhaetian aged rocks (Penarth group). The deformation mechanism during early rifting is discussed here based on the wide occurrence of these soft soft sediment deformations. Structural studies and sedimentological analysis were performed on logged sedimentary sections exposed along coastal outcrops along the Devon coast and the Seven Estuary, and in onshore cores from the Rathlin and Larne basins in Co. Antrim, Northern Ireland. Correlation of these data from Northern Ireland to Southwest England allowed the following common characteristics to be recognized: Deformation of the sediments was the result of earthquake related shocks. The direction of the various structures (folds, faults, injective bodies, etc.) is generally consistent in a particular locality, indicating a constant direction of the horizontal stresses; Several shocks were registered in the sedimentary pile. A mechanical stratigraphy controlled the location of the deformation. Together with the principal tectonic trends active during this period in the U.K., these data indicate that early rifting and the first stages of basin development were characterized by a complex multidirectional pattern of faults on which inherited basement structures played a major control. We further suggest that strain in this tectonic context was accommodated along many active faults that were distributed over a large area and experienced slip with low magnitude, possibly frequent, earthquakes.

HIGH-RESOLUTION CORRELATION IN CONTINENTAL-TO-MARINE SECTIONS BASED ON $\delta^{13}C$ SIGNAL: AN EXAMPLE FROM THE EARLY EOCENE OF THE SOUTH-PYRENEAN FORELAND BASIN (SPAIN)

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Geochemical signals in the sedimentary record have proven to be, amongst other markers, a cornerstone in the perspective of unravelling Earth's past climatic history.

In order to better understand the evolution of ancient deposits, from their transfer and storage from feeding systems to their distribution within different segments of a sedimentary basin, in this work we measure and trace a climatic and sediment pulse signal in the slope deposits of the early Eocene Pyrenean Ainsa basin (south-central Pyrenees, Spain), and correlate it with its time equivalent transitional to terrestrial deposits of the Tremp-Graus basin.

Several assumptions about the mechanisms driving the deposition in the different sedimentary environments involved are put forward and allow us to propose a high resolution correlation and timing model between four composite sections ranging from the fully continental fluvial Castissent Formation section in Mas de Faro, to the deep marine Pueyo section, including the turbiditic systems of Fosado, Arro and Gerbe.

Our data suggest that multiple controlling factors can be identified in both the marine and the continental depositional systems and we therefore attempt to untangle climatic, eustatic and tectonic drivers from each other with the aim of reconstructing a source-to-Sink history of the basin during this period in the lower Eocene.

To address this problem, we use stable isotopes on bulk rock carbonates to trace sea level variations and combine this method with elemental analysis, allowing us to corroborate and interpret independently the data set.

This correlation model is also based on fieldwork and previous mapping, and permit us to test some fundamental sequence stratigraphy models and debate about the factors controlling stratigraphic patterns in fluvial successions. These are still debated today, such as the preservation of a signal in continental environments during generation of a sequence boundary.

INFLUENCES OF DEPOSITIONAL FACIES ON COALBED METHANE ACCUMULATION: A CASE STUDY OF THE QINSHUI BASIN IN NORTHERN CHINA

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In China, the southern part of the Qinshui Basin has proven to be one of the most important coalbed methane (CBM) production base. However, a breakthrough development of CBM exploitation in the northcentral basin has not yet been achieved. One significant reason is a lack of understanding of the relationship between gas content and depositional facies. Based on a study of the lithofacies palaeogeography of the Taiyuan and Shanxi Formations in the Qinshui Basin, northern China, the changes of coal thickness, gas content, physical properties of the coal reservoir, together with the characteristics of surrounding rock of each palaeogeographic unit were investigated. The results show that the coal seams in the Taiyuan Formation were formed in a coastal plain environment, of which the coal-accumulation centers were migrated to the north gradually. Whereas the coal seams in the Shanxi Formation were deposited in a coastal delta environment, and the thick coal seams are mainly located in the south-central basin. The vitrinite content and vitrinite–inertinite ratio, for No.15 coal seams in the Taiyuan Formation and No.3 coal seam in the Shanxi Formation, decrease northward and the highest values are located in southeast margin of the basin. Furthermore, the vertical stratigraphy of Taiyuan Formation is: mudstone at the bottom; continuous, thick coal seams and limestone in the middle; along with discontinuous, thin coal seams, limestone, sand-mud interbeds on the top. Additionally, the stratigraphy of Shanxi Formation is: continuous, thick sandstones at the bottom; thick coal seams in the middle; along with thin coal seams, sandstone, thick mudstone on the top. Based on similar burial depths, the gas contents of the coal seams present in the Taiyuan Formation, in descending order, were as follows: No.9 seam, in a lower delta plain setting; No.15, in a lower delta plain setting; No.15, in a barrier-lagoon setting; No.15, in a delta front setting; No.15, in a barrier-tidal flat setting; and No.15, in a carbonate platform setting. The CBM enrichment areas tended to be located in zones of poorly developed limestone, and well developed mudstone. Meanwhile, the gas contents of Shanxi Formation were higher in the delta front than in the lower delta plain, and the enrichment areas were controlled by the thickness of the mudstone in the distributary bay.

RESPONSE OF UNCONFINED TURBIDITY CURRENTS TO COMPLEX TOPOGRAPHY IN DEEPWATER FOLD AND THRUST BELTS

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Complex seafloor topography observed within deepwater fold and thrust belts can have a substantial effect on the behaviour of turbidity currents and the ensuing sediment distribution. As these sediment-gravity flows are the primary mechanism for delivering sediments into deep ocean environments, an increasing number of studies are focusing on understanding the influence of seafloor topography on these sediment routing systems. Turbidity currents are difficult to study in the modern environment: measurements of sediment flux and flow velocities are challenging to measure, while flume tank experiments can struggle with scaling factors, short duration of the flow and oversimplified topography. Computational fluid dynamics (CFD) provides numerical solutions to physical equations describing fluid flow and sediment transport. As such, CFD modeling can be used to connect observations made in modern environments, flume experiments and the stratigraphic record. In the hydraulic domain, CFD allows us to study the influence of initial flow characteristics (e.g. flow size, density and grain-size composition) on the ability of turbidity currents to overcome topographic obstacles. In the topographic domain, it is crucial to account for the most common tectonic structures and their effect on the seafloor morphology. This study presents a series of simulations within the CFD software Flow 3DTM which describe the reflection (complete and partial) and confinement of flows by seafloor topography (modelled in Trishear 3D©) typical for deepwater fold and thrust belts. Parameters of both domains (hydraulic and topographic) are varied based on a range of case studies. Modelling results will be compared to sedimentary structures observed in outcrops and in flume tank studies, as well as erosional and depositional geometries seen in seismic data. Particular attention is given to negative fluid velocities within the bore where the flow is reflected and propagated upstream. The reflected bore can take many forms (generally defined as the ratio of the inflated bore to the forward flowing feeding current) and is believed to be mainly determined by the current velocity, volume sediment concentration and dip of the backlimb (primary limb encountered by the flow). The influence of varying structural geometry on the downstream behavior of the current will also be investigated. Preliminary interpretations observe flows displaying complete reflection to contain considerable sediment deposition in front of the fold and along the gently-dipping backlimb, while flows displaying partial reflection contain most of the deposition along the backlimb with minor amounts on the steeply-dipping forelimb. Interpretations from the simulation's comprehensive 3D modelling domain will complement current concepts, some of which are limited to 2D domains. As such, this study provides new insights into the effect folds have on the flow hydraulics and sediment dispersal of unconfined turbidity currents.

GROWTH PATTERN REGIMES OF SUBMARINE FANS ILLUSTRATED BY DEPTH-AVERAGED MODELS

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In deep water reservoirs where data needed to constrain critical stratigraphic information is limited or expensive to collect, a hierarchical physics-based approach is needed to integrate experiments, mathematical models, oceanographic observations of modern systems, and ancient outcrop.

Submarine fans are distributive channel systems that range over three orders in magnitude in size (10-1000 km) inversely correlated with three orders of magnitude in slope and are therefore hydraulically and morphodynamically diverse. Although sediment transport equilibrium (grade) from fluvial systems has been postulated as a viable concept for submarine fan interpretation and prediction, most sediment is deposited out of equilibrium. Distributive systems, by their very nature are seldom at grade and their constant oscillation around the graded slope due to autogenic avulsion cycles controls much of the fan stratigraphy. At a larger scale the gradient of the entire basin drifts over time driving a systematic change in fan organization.

Here we test the hypothesis that oscillations around equilibrium are controlled by avulsion cycles that can be divided into distinct morphodynamic regimes based on the hydraulics (i.e., Froude Number) and sediment transport mode (e.g., sand/mud ratio). These principles were first elucidated in “shallow water” tank experiments like deltas and alluvial fans, where supercritical systems with sufficient bedload tend to be dominated by hydraulic jumps and choke by mouth bars. For the case of subcritical flow, two avulsion styles are recognized: (a) feedback and sandy channel fill related to short backwater lengths interacting with mouth bar choke (i.e., morphodynamic backwater) and (b) a long (hydraulic) backwater mode controlling the size of the delta and filling the channel with mud. These avulsion cycles are also observed in submarine fan experiments, yet due to scaling limitations the dynamic range of these experiments has been limited.

ExxonMobil Upstream Research Company is developing a fast (parallelized) simulator to investigate the dynamics of submarine growth patterns and avulsion cycles. A depth-averaged approach is applied to attain sufficient simulation speed to enable significant stratigraphic development (millennia with continuous flow) and to test the aforementioned stratigraphic concepts. Results from the new model indicate that while the smallest coarsest grained fans tend to be supercritical and the largest tend to have large regions of subcritical behavior, the most dynamically rich are transcritical fans, oscillating between supercritical and subcritical flow. The results also indicate that stratigraphic style can change suddenly as the system crosses a threshold in the dynamics during an avulsion cycle and that on average the lower and upper sections of a basin may have a different stratigraphic style with a sharp boundary between them. This boundary is interpreted as a dynamic threshold occurring at Froude critical flow. A key aspect in understanding the relevance of the model results is determining the range of validity of the vertically averaged flow approximation as turbidity currents approach the basin floor.

SHELF MARGIN GROWTH RESPONSE TO PLEISTOCENE GLACIOEUSTASY IN CANTERBURY BASIN, OFFSHORE NEW ZEALAND

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The Canterbury Basin lies on the eastern margin of South Island in New Zealand and the Neogene strata underlie from onshore Canterbury Plain to offshore continental shelf. Lu and Fulthorpe (2004) recognized Miocene-Holocene sequence boundaries based on the interpretation of 57 two-dimensional seismic profiles and the ages from industrial wells. IODP Expedition 317 drilled on the shelf and the upper slope in 2009 and Hoyanagi et al. (2014) proposed the precise Pleistocene age model for the slope core based on the study of oxygen isotope ratios of benthic foraminifera fossils.

We reinterpreted seismic sequence boundaries in the seismic profiles and tried to correlate them with facies discontinuities in the cores. We found seven discontinuities in the cores, which placed the same depth of seismic sequence boundaries. We recognized them as the sequence boundaries and named them SB1 to SB7 in descending order. The lowest sequence boundary (SB7) coincides with hiatus between 2.7 and 1.8 Ma representing the discontinuities in the cores from shelf and slope. Based on the age model of slope core, the sequence boundaries SB1 to SB6 were formed during the glacial stage of MIS 6, 8, 12, 22 and 58 respectively. We have reconstructed the 3D shelf and slope geomorphologies from the spatial distribution of some sequence boundaries. The 3D models show that the shelf edge migration and gradient change of the slope. The slope gradient was gentle and sedimentation occurred on the slope toe at 1.8 Ma. While during the Mid-Pleistocene Transition (MPT: between 1.3 and 0.7 Ma), the sediments deposited on upper slope and the gradient of slope slightly steeped. After the MPT, wide amplitude of sea level variations has caused rapid progradation of the shelf edge and the slope gradient has become steeper.

QUANTITATIVE LITHOFACIES PALEOGEOGRAPHY RESEARCH: A CASE FORM ORDOVICIAN MAJIAGOU 54 SUB-MEMBER IN THE WEST JINGBIAN PLATFORM, ORDOS BASIN, CHINA

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The fourth Sub-member, the fifth Member, Majiagou Formation (hereinafter referred to as Ma54) of Middle Ordovician is the important gas exploration layer in Ordos Basin, but many lithofacies paleogeographic maps about this layer are based on member or sub-member unit and is with a basin scale, and their resolution is far away from the requirement of gas exploration and development. In this paper, according to paleogeomorphology, anhydrite type and its paleoenvironment significance, lithofacies paleogeography will be mapped in the M54 divided into Ma543, Ma542 and Ma541 in west Jingbian platform, which fills the gap of lack high-resolution maps. On the base of sedimentary setting and stratum thickness contour diagram, the thick and slightly steep area in the center is interpreted as depression, and the thin and gentle area around the depression is interpreted as flat. There are massive anhydrite, spherical anhydrite concretion and anhydrite crystal in Ma54. Massive anhydrite interbeded with dark muddy algae laminar dolomite represents a shallow and subaqueous evaporative environment which is located in supratidal zone and is sometimes flooded by tide water. Spherical anhydrite concretions, which are dispersed in light yellow micritic and slit-sized crystal dolostone, are formed during penecontemporaneous stage and indicate an evaporative and oxidizing environment with variational salinity. Comparison with the other two types of anhydrite, anhydrite crystals aren't very common, and most of them show a columnar shape. Some anhydrite crystals associate with spherical anhydrite concretion, so their environment is as same as spherical anhydrite concretion's. Massive anhydrite is distributed in the depression, so the lithofacies paleogeographic name is called anhydrite depression. According to the content of massive anhydrite, anhydrite depression is divided into massive anhydritic dolomite depression, massive anhydrite dolomite depression and dolomitic massive anhydrite depression. Spherical anhydrite concretion and anhydrite crystal are mainly distributed in flat. Combined their distribution and sedimentary setting of restricted evaporative supratidal zone, they are called spherical anhydrite concretion dolomite tidal flat. The basic lithofacies paleogeographies of Ma543, Ma542 and Ma541 are almost the same, but from Ma543 to Ma542 and then Ma541, the anhydrite depression becomes smaller and smaller, and the content of massive anhydrite decreases gradually, which shows the process that supraltidal evaporative water becomes shallower and shallower. This paper makes some relative high-resolution lithofacies paleogeographic maps, which is very helpful to the gas exploration and development in Lower Paleozoic in Ordos Basin.

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PRELIMINARY RESEARCH ON LOGGING CHARACTERISTICS OF PALEOSOL LAYER

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Lots of outcrop researches show that paleosol is a good marker bed to high-resolution stratigraphic correlation in fluvial strata, but it is still a great challenge to identify paleosol in subsurface by core and wireline-log. According to the research of Hampson et al. (2005) on the Cretaceous Blackhawk Formation and Castlegate Sandstone in Book Cliff, Utah, USA, high Th/K in spectral gamma-ray is a good marker to identify paleosol. The high Th/K is interpreted that surface leaching depletes some potassium. After this viewpoint, we find abnormal high Th/K at the top of the 8th Member, Lower Shihezi Formation in Sulige area, Ordos Basin, China. And its corresponding core are red-purple-grey mudstone without root trace, which is the weathering products of flooding sediments in semiarid-arid climate. The analysis shows that abnormal one layer of high Th/K is usually corresponding to a few layers of 'low DEN + high CNL' (i.e. assembly of low density and high neutron logging). In theory, surface leaching effect results high Th/K, and it can also form better permeable layer in mudstone, which is characterized by 'low DEN + high CNL'. Further analysis indicates that the core of some 'low DEN + high CNL' layers without abnormal Th/K is purple-red mudstone which is just low maturity paleosol. The 'low DEN + high CNL' may be the result of exposed, weathering and lightly leaching. Thus, 'low DEN + high CNL' layer shows higher resolution to identify subsurface paleosol by logging. However, the correlation between abnormal high Th/Kand 'low DEN + high CNL', and the value range of 'low DEN + high CNL' indicating low maturity paleosol are unsure, and they will be researched in the future work. This work will be very significant to subsurface fluvial strata correlation.

WESTERNMOST PROTO-NORTH ATLANTIC NERITIC ARCHIVES OF BARREMIAN-APTIAN ENVIRONMENTAL CHANGE

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Shallow-water carbonate platforms situated at the Northern Tethyan margin witnessed a major crisis prior to the ocean-wide deposition of organic rich 'black shales' associated with the Early Aptian oceanic anoxic event (OAE) 1a. The demise, shutdown and (often diachronous) drowning were accompanied by a pelagic biocalcification crisis affecting calcareous nannoplankton. In contrast, ongoing Early Aptian carbonate production documenting a replacement of oligotrophic, rudist-coral dominated assemblages by other environmental-stress adapted carbonate platform communities (orbitolinids, *Lithocodium aggregatum-Bacinella irregularis* microencrusters) have been reported from eastern proto-North Atlantic (Portugal) and central and southern Tethyan (Croatia, Oman) shallow-water settings. Although the controlling factors of this ecological change still remain poorly understood, the stratigraphic and spatial distribution of Early Aptian neritic palaeo-ecological turnovers clearly demonstrates a rather complex pattern and arguably a causal relation to the progressive installation of stressors related to OAE1a.

At present, high-resolution data sets on palaeo-ecologic and palaeo-oceanographic patterns from the middle Cretaceous (Barremian-Aptian) of the western proto-North Atlantic realm are comparably scarce or absent. Therefore, an in-depth sedimentological-chemostratigraphic approach has been applied to an expanded (mixed carbonate-siliciclastic) Upper Barremian-Lower Aptian shallow-water section (Barranco San Lucas) located in central Mexico (San Juan Raya, Puebla). The main focus was on (i) identifying suitable biostratigraphic index fossils (ammonites, microfossils) and (ii) establishing a high-resolution integrated chemostratigraphic shallow-water reference framework (bulk $\delta^{13}C$ and $\delta^{13}C$, bivalve shell $\delta^{13}C$ and $^{87}Sr/^{86}Sr$).

Whereas bulk samples (marls, silts, argillaceous limestones) derived from the Aptian portion of the studied section (San Juan Raya Fm.) provide evidence for a significant diagenetic overprint with strongly ^{18}O and ^{13}C-depleted values, data obtained from the Barremian portion (Zapotitlan Formation) show a well-preserved chemostratigraphic pattern that is characterized by a prominent positive carbon-isotope excursion followed by a negative spike at the Barremian-Aptian (?) transition. Carbon-isotope results of bivalves collected from the diagenetically altered San Juan Raya Fm. are used to complement the chemostratigraphic record upsection. Unfortunately, strontium-isotope results indicate a substantial input of continentally derived radiogenic isotope signatures, recorded by oyster shells derived from predominantly siliciclastic units. Organic carbon carbon-isotope results provide a solid pattern characterized by gentle sinusoidal fluctuations, but the prominent negative excursion indicating the onset of OAE1a has not been detected. Despite this rather complex and diagenetically altered chemostratigraphic framework, the clearly most interesting observation is the presence of a *Lithocodium aggregatum* interval spanning large parts of the Barremian Zapotitlan Fm. In its habit and morphology, this Lithocodium mass occurrence shares important similarities with similar occurrences from the eastern margin of the proto-North Atlantic in Portugal, the latter having been ascribed to the earliest Aptian. By assessing additional biostratigraphic and chemostratigraphic results, we will be able to document the either coeval or diachronous nature of *Lithocodium aggregatum* microencruster events at both margins of the opening proto-North Atlantic, allowing for the consideration of this paleo-ecological pattern from a much wider perspective.

EXPLORING THE CONTROLS OF EARLY APTIAN TETHYAN AND PROTO-ATLANTIC REEFAL PALAEOECOLOGY TURNOVER

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Evidence has been given that a series of Tethyan-wide (Oman, Croatia) and proto-Atlantic (Portugal) shallow-water carbonate platforms recorded fundamental biotic turnovers in the prelude, during, and in the aftermath of the Lower Aptian Oceanic Anoxic Event (OAE) 1a. Coral-rudist ecosystems were temporarily replaced by taxonomically problematic microencruster communities referred to as Bacinella irregularis and Lithocodium aggregatum, but little is known about the triggering factors that control the temporal dominance of the latter. Our working hypothesis is that in the context of the larger OAE1a, reduced dissolved seawater-oxygen levels of Lower Aptian shallow neritic water masses temporarily impaired oxygen-dependent coral-rudist communities as efficient neritic carbonate producers. Rare Earth Element (REE) patterns, particularly Cerium anomalies, as well as Uranium isotope ($^{238}U/^{235}U$) analysis are used in this study as proxies for seawater redox conditions. In combination with detailed fieldwork and thin section analysis, these proxies represent a powerful tool to reconstruct the seawater-oxygen content prior and during the OAE 1a time interval. First REE and $^{238}U/^{235}U$ results from the Kanfanar section in Croatia show a significant decrease in dissolved seawater-oxygen at the beginning of laminar and massive Bacinella irregularis and Lithocodium aggregatum growth, though to be occurring slightly after the onset of OAE 1a. These data may point towards a dichotomy of oceanic oxygenation levels between the deep and shallow marine area, although uncertainties in the stratigraphic attribution of the OAE 1a interval in the Kanfanar section need to be resolved. Given the coeval onset of massive microencruster growth and neritic oxygen level depletion in Kanfanar, the hypothesis of neritic (sub)anoxia as the main controlling factor for the palaeoecological turnover seems plausible. Further work will focus on the importance of regional factors, here particularly the formation of regionally limited, platform top anoxic water masses, overprinting a global environmental trend that finally culminated in OAE1a-related basinal black-shale deposits.

ALLOGENIC VERSUS AUTOGENIC CONTROLS ON A FLUVIAL-FAN SUCCESSION: A COMPOSITIONAL STUDY OF THE CACHEUTA BASIN INFILL (CENTRAL ARGENTINIAN FORELAND)

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Sediments deposited in foreland basins are accurate recorders of processes acting at different temporal and spatial scales during orogenic uplift. The effects of allogenic forcing on foreland sedimentation are usually well constrained at basin-scale in the literature, but uncertainties remain in deciphering and interpreting them at high stratigraphic resolution, and in differentiating them from the signatures of autogenic processes.

We present observations on the continental sedimentology and stratigraphy of the Cacheuta Basin (Mendoza Province, Central Argentinian Foreland), aiming at a detailed reconstruction of paleoenvironmental dynamics and unraveling the relative roles of climate, tectonics, and autogenic processes in driving compositional changes through the clastic infill. This is attained combining a high-resolution, integrated compositional analysis (mineralogy, whole-rock and isotope geochemistry) with sedimentological observations and stratigraphic correlations of two principal transects at an approximate distance of 10 km. The majority of the basin infill is comprised by the Mariño and the La Pilona formations, deposited during the Miocene and comprising almost 2000 m of stratigraphy. The large-scale stratigraphic trend leads to interpret the entire alluvial succession as the product of progradation of a fluvial-fan system originating from the orogenic basin margin. The basin infill records relatively continuous sediment supply from the rising Principal Cordillera and the first stages of the uplift of the Frontal Cordillera. Compositional changes of the clastic infill record the interaction of different allogenic factors, but also of autogenic processes.

Bearing in mind the geometry of fluvial-fan systems, characterized by lobate deposits finite in length and width, the effects of the main forcing factors on the compositional variations of the sedimentary successions are related to the progradation of the fluvial-fan system. Compositional changes driven by allogenic forcing have a widespread signature, changing the composition of the sediments deposited on the entire fluvial fan system and offering clear correlatable compositional units between the two studied sections. However, autogenic processes acting at system scale also influence variations in sediment distribution and composition, and thus the sedimentological and compositional interpretation of the basin fill, adding a potential complication in evaluating the role of allogenic forcing.

The compositional data documented here provide a good base to distinguish system-scale autogenic from allogenic mechanisms in governing the overall stratal architecture of the Cacheuta Basin. Tectonic and climatic signals in compositional change are recognizable based on specific and combined proxy data. The gradual compositional trends through stratigraphy indicate continuity in sedimentation within the interpreted framework of progradation of a fluvial-fan system affected by hinterland tectonic and climatic changes. Large-scale trends in vertical facies abundance and architecture through the alluvial strata are likely related to the inherent tendency of fluvial fans to preserve and increasingly amalgamate coarse-grained channel-belt and channel-fill deposits on their proximal domains.

Besides providing extensive outcrop analogues for the characterization and prediction of comparable sedimentary complexes in the subsurface, this project represents a significant, ground-based assessment of mineralogical and geochemical methods for reservoir correlation and evaluation.

HAUTERIVIAN TO ALBIAN STABLE CARBON-AND OXYGEN-ISOTOPE RECORD AND ITS RELATION TO OAES AND ~9 M.Y. AND ~400 K.Y. RELATIVE SEA LEVEL CHANGES, ADRIATIC PLATFORM, CROATIA

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The Mljet and Korčula islands of southern Croatia expose carbonates of the Adriatic Platform, a large intraoceanic, Mesozoic carbonate platform, several hundred kilometers long, with a present width of ~200 km within the Dinaride fold thrust belt. The $\delta^{13}C$ (and $\delta^{18}O$) stratigraphy is based on lime mudstone matrix generally sampled at 1 m intervals (which is less than the 1.5 m mean parasequence thickness). Dolomites and diagenetically altered, cement-bearing packstones and grainstones were excluded from this study. The studied 700-m-thick Hauterivian to Albian Adriatic Platform section underwent little post-Mesozoic burial and so the finer grained facies escaped significant later burial diagenesis. However, overall the lime mudstones are shifted slightly towards more negative $\delta^{13}C$ and $\delta^{18}O$ values, perhaps as a result of some early diagenesis beneath the numerous emergence surfaces in the section. The smoothed $\delta^{13}C$ and $\delta^{18}O$ record from precursor calcite lime mudstone matrix provides one of the most continuous stable-isotope curves from an Early Cretaceous platform. This record captures the carbon isotope excursions (CIEs) and oceanic anoxic events (OAE1a, b, c) evident in published hemipelagic sections, with the added advantage of preserving a record of associated relative sea level changes. The platform facies appear to have been little affected by the OAEs, except for OAE1a when deposition of organic-rich laminated limestones occurred in local tectonic intra-platform depressions. These tectonic downwarps heralded later widespread Late Cretaceous deformation of the platform. During OAEs the shallow platform-top waters generally remained relatively well mixed and oxygenated, and above the zone of poorly oxygenated bottom waters. Excluding the slowly accumulating Aptian, the smoothed $\delta^{13}C$ and $\delta^{18}O$ platform curves exhibit fluctuations with a mean thickness of 15 m (~400 k.y. duration) driven by eccentricity modulation in which many of the negative excursions (climate warming) tie to periods of platform submergence characterized by poorly cyclic intervals. Conversely, most positive peaks of 400 k.y. cycles on the smoothed $\delta^{13}C$ and $\delta^{18}O$ record match short periods of minimum accommodation and thinner than average cycles, suggestive of cooling and relative sea level fall. There also are weakly developed ~9 m.y. duration, $\delta^{13}C$ eccentricity modulation cycles whose positive excursions generally match times of peak accommodation.

NEW INSIGHTS FROM SUMMER PALEOTEMPERATURES DEDUCED FROM STABLE ISOTOPE ($\delta^{18}O$) COMPOSITION OF SHALLOW-MARINE AND NON-MARINE ALGAE IN THE PALEOGENE OF THE PARIS BASIN

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Paleogene paleoclimatic data originate mainly from the $\delta^{18}O$ of deep-sea benthic foraminifers and to a lesser extent from planktonic foraminifers. These previous works have successfully documented that the Palaeogene experienced a long-term and discontinuous cooling starting from the greenhouse Early Eocene Climatic Optimum up to a permanent icehouse world since the EoceneOligocene boundary (~ 34 Ma). However, the deep-sea record presents some limitations because only mean annual temperatures can be estimated from these proxies and important climate parameters such as the seasonal gradient of temperatures cannot be adequately informed. Moreover, oceanic environments are less sensitive to short duration and low intensity climatic events, giving a partial vision of the Cenozoic climate. In addition, it would be particularly significant to characterize how other environments like coastal and non-marine domains have been affected by these temperature fluctuations during this major climatic transition. In this study, we test the potentiality of using dasycladales and charophytes, calcareous shallow-marine and non-marine algae respectively as palaeoclimatic recorders. These algae mineralize their carbonate during short periods in summer. Throughout the Palaeogene, we compare the $\delta^{18}O$ record of these two taxa to identify a possible common factor influencing their isotopic composition, i.e. temperatures variations, from a local environmental signal. We sampled and isotopically analyzed eight species of charophytes and seven species of dasycladales from 23 formations ranging from the Palaeocene to the Oligocene deposits of the Paris Basin. By comparing the $\delta^{18}O$ of these two groups living in different environment with that of shallow-marine mollusks from a previous study, we show that temperature variations are the main factor influencing their $\delta^{18}O$ compositions and that local environmental effects do not disturb the overall thermal signal. Maximum annual palaeotemperatures are calculated from the $\delta^{18}O$ of the dasycladales and indicate by comparison with the data of previously analyzed mollusks that dasycladales species used probably mineralized their carbonate in equilibrium with sea-water. Dasycladales recorded the global climatic events already known for the Palaeogene, with high temperatures reached during the Early Eocene and Middle Eocene climatic optimums and relative cooling intervals during the Lutetian, the Priabonian and the Rupelian. Charophyte gyrogonites also recorded temperature variations in their $\delta^{18}O$ compositions but reconstituting reliable temperature values in non-marine environments is not directly possible and requires constraining $\delta^{18}O$ of local continental water using other proxies. These promising preliminary results show that carbonates biomineralized from algae constitute a reliable support for palaeoclimatic information and should be more widely used in the fossil record of the European intracratonic basins.

PALEOCLIMATIC AND PALEOGEOGRAPHIC RECONSTRUCTIONS OF THE CRETACEOUS AND PALEOGENE OF THE VOLGA REGION ON THE BASIS OF K-AR ISOTOPIC DATA OF X GLOBULAR LAYERED SILICATES

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When analyzing clay minerals in order to restore paleoclimatic and paleogeographic conditions, it is necessary to use a set of methods in order to uniquely divide the minerals of terrigenous and authigenic genesis. Of great interest are the discoveries of minerals, the formation of which can be considered syngenetic. Among clay minerals, glauconite formation can be attributed to this group, which begins at the stage of sedimentogenesis or early diagenesis. For the formation of glauconites, the mobilization of solutions containing elements is necessary to construct a new structure-Si, Al, Fe^{3+}, Fe^{2+}, Mg, Ca, K, Na, H^+, OH^-, F. Glauconite is formed in the transition medium from oxidative (with hydroxides of iron and manganese) to reducing (with iron sulfides). Authigenic glauconites can be used as paleothermometers of sea water and are usually associated with climatic optima. There is an opinion that the formation of glauconite is intensified during major transgressions due to the fact that during the transgressions the burial of precipitation is accelerated, as well as due to the likely strengthening of the connection between the epicontinental basins and the oceans and the receipt of deep ocean waters enriched with biogenic elements. The K-Ar age of the GSS of the chalk and the Paleogene is 83.0 ± 2 and 64.0 ± 1.5 million years, respectively, which corresponds to their stratigraphic position.

Glauconites of Campanian and Zealandian are characterized by a fairly similar structure and refer to the modification of 1Md. Grain is characterized by sufficient maturity and is characterized by a high content of iron and potassium. Grains do not carry traces of transference and can be regarded as authigenic. The magnesium content of sedimentary formations is often associated with the salinity of the paleobasin sea water, with a direct relationship between salinity and seawater temperature. As a result, the magnesium content of the glauconite can be used to calculate the average paleobasin temperature. The temperature in the Campanian can be calculated on the order of 20° C, while in the Paleogene it is about 22° C.

Given that, probably, diagenesis in the studied sediments proceeded according to a similar scenario, the apparent differences in the composition and structure of glauconite are due to paleoclimatic conditions. In the Campanian time there were relatively cooler and humid conditions, which contributed to an increase in the content of smectite and as a result led to the formation of glauconite distributed over a wider range of densities. Grains can be characterized as more friable, characterized by smaller crystallite sizes with the same degree of structural ordering. The presence of smectite in grains of glauconite confirms the incompleteness of the process of their formation. At the same time, the coastal zone in the Cretaceous was closer than in the Paleogene, when more large-crystalline glauconites without smectite admixture were formed

THE DEEP FRONTIER OF CARBONATE DIAGENESIS

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Following deposition, precipitation, or secretion, most carbonates undergo burial, diagenetic alteration and eventually metamorphic overprint turning into marbles (or worse). The processes, products, and pathways of earliest to deep (late) burial carbonate diagenesis have been the topic of numerous studies, both in academia and industry. Along similar lines, metamorphic petrologists have studied low to mid-grade metamorphic marbles in orogens and beyond, often formed in contact with regional metamorphism including igneous intrusions. Threshold criteria that define the transition between diagenesis and metamorphosis have been discussed in the literature but none of these is universally applicable to carbonates. Inconsistency prevails regarding the deep frontier of carbonate diagenesis from the viewpoint of the sedimentologists, and for the onset of low-grade metamorphosis as defined by petrologists. This issue becomes particularly obvious as different sedimentary facies respond remarkably different to burial. Carbonates undergo recrystallization, neomorphism, dolomitization and the like at depths of some tens to hundreds of meters and ambient temperatures of tens of degrees, whereas mature quartz sandstones may display little evidence for alteration, other than compaction and cementation, even at burial depths in excess of 9000 m and temperatures of 230°C. Given that the transition between diagenesis and metamorphosis is gradual and fluctuates for different rock types, any boundary must be arbitrarily established. Additional complexity lies in the fact that depth temperature gradients differ within one basin and between different basins and between continental and oceanic settings. In practice, it is difficult to pinpoint a fixed isothermal boundary that can be applied in a similar manner to all basins and particularly so for the case of carbonate rocks. The term anchimetamorphosis (i.e., the very low stage of metamorphosis) refers to a transitional depth window between roughly 200 and 350°C and covers the poorly-defined anchizone situated between deep burial diagenesis and metamorphosis. Judging from published work, the shallow upper boundary of the anchizone (and hence the deep frontier of diagenesis) is reached at a temperature of roughly 200°C and a burial depth of about 6500-8000 m. From the viewpoint of carbonate sedimentology and archive research, the significance of these considerations lies in the fact that there is no simple relation between petrographic and geochemical properties of buried carbonates. Some of the calcitic Carrara marbles, to name but one example, yield carbonate clumped isotope temperatures (D47) clearly in excess of 200°C whilst their conventional $\delta^{18}O$ signatures applied to temperature equations suggest burial temperatures of less than 20°C and their $\delta^{13}C$ signatures show typical "marine" values. This raises questions regarding the significance of burial temperatures and the issue of "dry diagenesis", i.e. the burial of "dense" limestones that are impermeable for reactive burial fluids except where tectonically-induced pathways exist. These observations are of significance for example for many Precambrian carbonate rocks that have seen poorly constrained degrees of diagenetic- and perhaps anchimetamophic-overprint and yet these are exploited as archives of their palaeoenvironment.

HYDROTHERMAL FLUIDS IN THE PYRENEAN HYPER-EXTENDED RIFT SYSTEM: NEW OBSERVATIONS AND INTERPRETATIONS FROM THE CHAÎNONS BÉARNAIS (WESTERN PYRENEES)

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The evolution and formation of passive rifted margins is strictly linked to different geological processes in which fluids activity is much more important and diffused than previously thought. Nonetheless, the physico-chemical properties, the pathways and source areas of these fluids are still little studied and understood, especially in the sedimentary environment. This contribution aims exactly to shed light on the interaction between fluids and sediments within the hyper-extended parts of the Mauléon Basin. The target of the study is the carbonate, pre-to syn-rift, sedimentary sequence cropping out along the eastern termination of the Chaînons Béarnais. The attention has been focussed on the post-depositional modifications of the host rocks due to hydrothermal fluids. The Chaînons Béarnais are interpreted to be extensional allochthons over long offset detachment faults that were responsible for the exhumation of mantle rocks at the seafloor during mid-Cretaceous time. As already demonstrated in previous studies, both in the Pyrenees and the Alps, the extensional tectonic affecting rifted margins is deeply associated to impressive volumes of fluids interacting with basement and sedimentary rocks. Strong field-and petrography-based evidence of fluid-related products will be shown referring to Jurassic-Cretaceous rifting events in the easternmost Mauléon basin. Such geological constraints are then supported by analytical data, which point to the occurrence of very hot fluids (up to 250°C with highly depleted $\delta^{18}O$) responsible for several different structures. It has also been possible to re-interpret the lithostratigraphy of the studied area and to link well-described process (e.g. albitization) affecting the central and eastern Pyrenees to the evolution of the Chaînons Béarnais. The evolutionary model of the study area comprises two main stages distinguished on the basis of the chemistry of fluids. The first, carbonate-rich, led to fabric-destructive replacement dolomitization of the host carbonates, widespread hydrofracturation generating different types of hydraulic breccias cemented by multi-phase dolomite and calcite and, finally, micro-to meso-scale fracturation and veining. The second stage, dominated by $Na\text{-}SiO_2^-$ rich fluids, as the occurrence of authigenic albite and quartz demonstrates, affected mainly syn-rift deposits.

Findings of authigenic sulphides point to an even more complex fluid system. Finally, dolomite marbles and mylonites provide evidence for strong recrystallization and ductile shearing. The study area shows clear evidence of marked fluid circulation as well as different deformation styles making the interpretation of the overall context as complex as demonstrative of the importance of fluids in the evolution of hyperextended rift systems. Each process reflects different physico-chemical conditions as the different resulting structures and fluid-related mineral phases document. Despite the lack of extensive outcrops, the Chaînons Béarnais represent a primary target to investigate fluid-rock interaction in response to extensional tectonics as also described for other analogues (e.g. Adriatic paleo-rifted margin) as well as present-day rifted margins (e.g. Iberia and Red Sea).

HYPER-EXTENSION AND HYDROTHERMALISM: COMPARISON BETWEEN PRESENT-DAY IBERIAN DISTAL MARGIN AND TWO FOSSIL ANALOGUES

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The connection between continental hyper-extension and hydrothermal fluid flow is becoming essential in the prediction of the thermal state and evolution of distal rifted margins. The role of fluids in determining post-depositional modifications of host rocks has a strong influence on critical parameters such as permeability, porosity and heat fluxes in sedimentary basins. The definition and understanding of processes related to fluid circulation is fundamental to establish the exact timing of their occurrence as well as their physico-chemical properties. Excluding proprietary data, only 18 drill holes are available on present-day passive margins so that the study of fossil analogues is crucial to overcome the lack of observations and to get reliable data to apply in present-day settings. The Adriatic paleo-rifted margin preserved in the central Alps is one of the most outstanding fossil analogues worldwide. Recent studies highlighted the importance of fluid activity in terms of mass and heat transfer along the different stages of the extensional evolution of the margin. Such fluid circulation took place within both basement rocks and pre-to post-rift sediments where undisputable geological proofs constrain the fluid activity in the time range (Upper Triassic-Middle Jurassic) when the margin developed. The Pyrenean hyper-extended rift system in the western Pyrenees show similar features to the Alpine counterpart: long off-set low-angle detachment faults, extensional allochthons made of pre-rift carbonates and syn-rift deposits filling supra-detachment basins. Also in this case, the preand syn-rift sediments display several evidence of the occurrence of overpressured hydrothermal fluids affecting the host rocks during Jurassic-mid Cretaceous rifting events. The multi-disciplinary approach adopted to study these paleo-margins allowed to depict a complex evolutionary fluid flow model that can be summarized assuming two main stages. The first, characterized by carbonate-rich fluids took place in the early rifting stage leading to diffuse and fabric-destructive replacement dolomitization of the host carbonates, dolomite cementation of pores, hydraulic fracturation and subsequent cementation by dolomite and calcite, diffuse veining. The second involved silica-rich fluids related to the late rifting stage and that generated widespread fine-grained silicification, cementation of veins by quartz, albitization and the formation of silica-rich septarian-like concretions. The two stages show common features such as high temperatures (up to 250°C), strong $\delta^{18}O$ depletion, high $^{87}Sr/^{86}Sr$ ratio and very low He content pointing to hydrothermal cells mainly involving altered continental basement rocks and the overlying carbonate sequences. Finally, scientific reports from ODP Leg 103 in the present-day Iberian distal margin show that diffuse carbonate-rich fluid circulation within the pre-rift sediments gave rise to the same fluid-related products observed in the Alpine and Pyrenean examples (replacement dolomitization, brecciation, veining). Even if the analytical dataset is not as complete as those of the two fossil analogues, it clearly suggests that hydrothermal fluids were responsible for the observed post-depositional modifications. Therefore, the comparison of present-day passive margins and their fossil analogues represents a valuable tool in order to properly determine, define and constrain the extensional evolution of rifted margins being conscious about the strong link between the tectono-stratigraphic and fluid flow evolution.

ARCHITECTURAL ANALYSIS OF UPPER-SHOREFACE DEPOSITS AT INTRA-PARASEQUENCE SCALE: DIFFERENT MORPHOLOGICAL CONFIGURATIONS AND POSSIBLE CONTROLS

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It is commonly assumed that parasequences are the expression of a unique depositional system, prograding trough time. This would imply that internal bedsets within a parasequence should be composed of similar facies associations. However, careful inspection of upper-shoreface (and foreshore?) deposits at intra-parasequence scale in Cretaceous deposits of the Neuquén Basin revealed significant changes in the configuration of the nearshore system. The aim of this contribution is to describe different types of uppershoreface deposits within successive bedsets (of a single parasequence) in order to interpret changes in the morphology of the costal setting and to discuss the mid-term evolution of shallow marine systems.

The 30-m-thick PS400 parasequence of the Pilmatué Member (Late Valanginian-Early Hauterivian) has been investigated along a 12-km, dip-oriented, transect. This parasequence is composed of twelve bedsets, and facies associations suggest the long-standing development of a storm-dominated, shoreface-to-offshore system. All deposits, but those interpreted as reflecting upper-shoreface conditions, remain relatively constant through the unit. For the architectural analysis of the upper-shoreface deposits, outcrop sections 1-3 km wide and up to 5 m thick were selected. Detail sedimentary logs (15-30 m apart) were combined with mapping of internal surfaces.

On the basis of the architectural analysis, three types of upper-shoreface deposits were identified. Type 1 deposits, the most common through the unit, consists of one facies association composed of fine-to medium-grained siliciclastic or mixed (siliciclastic-carbonate) sandstones, with trough cross-stratification. Type 1 deposits, do not present internal surfaces. In Type 2 deposits, the previous facies association regularly alternates with ripple cross-laminated, unburrowed, fine-grained sandstones, forming packages up to 30 m wide. These packages are laterally bounded by tangential seaward-dipping surfaces (5-10°). Type 3 deposits are characterized by closely spaced, large-scale, concave-up to tangential foreset beds. These dip seaward up to 10° and represent the alternation of sandstones having parallel planar lamination or ripple cross-lamination, with pebbly, bioclastic sandstones showing trough cross-lamination.

The vertical and lateral relationships of upper-shoreface types suggests short-term accretion and seaward migration of a shoreline under different morphological conditions. Types 1 and 2 would likely reflect barred coasts, with a bar-trough system morphology. However, steep seaward-dipping surfaces and drastic lateral changes in Type 2 could be a response to a higher gradient. Foreset beds of Type 3 would also reflect high gradients, but in a non-barred coast.

The presence of three types of upper-shoreface deposits reflect an important variability in coastal morphology and dynamics at intra-parasequence scale frequency (possibly 10 kys) that might not be anticipated by looking at distal facies alone or without a detailed architectural analysis. Moreover, it suggests that controlling factors such as sediment supply, depth of receiving basin and/or wave climate changed trough successive bedsets. Specifically, high-gradient morphology, departing from the most common low-gradient, barred system (Type 1), could be related to an increase in sediment supply in Type 2, but to an increase in depth of receiving basin (and wave regime?) in Type 3.

STUDY OF PALEOZOIC RESERVOIR SYSTEMS IN THE GHADAMES AND JEFARAH BASINS

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Twenty-eight wells with its geological well reports and well logs from Paleozoic reservoirs the Ghadames and Jefarah basins (Libya) illustrate how reservoir properties changes laterally and vertically through time (from a proximal to a distal setting). Two softwares were used, JLog (version 4) petrophysical software for reservoir property analysis and PETREL (Schlumberger software 2014 version) for constructing stratigraphic correlation models. The reservoirs in the study area are spread over a large range of siliciclastic reservoirs with the prospective section extending from Cambrian till the Permian. Hydrocarbons within the Ghadames and Jefarah basins originated from two major source rocks, i.e. the Lower Silurian Tanezoft Formation and Middle-Upper Devonian Awaynat Wanin Formation. The nine main Paleozoic reservoirs are respectively the Hasawnah, Hawaz and Mamouniyat Formations (Lower Paleozoic), Akakus, Tadrart, Ouan Kaza and Tahara Formations (Middle Paleozoic) and M'rar and Asadjefar Formations (Upper Paleozoic). Six stratigraphic cross sections through the area have been reconstructed to illustrate the vertical and lateral reservoir extensions. The acquired dataset demonstrates that the Paleozoic reservoir properties are influenced by both, depositional facies and position within the paleogeographical setting (from proximal to distal part).

STRATIGRAPHY, SEDIMENTOLOGY AND PALEOGEOGRAPHY OF A PALEOZOIC SUCCESSION, GHADAMES AND JEFARAH BASIN, LIBYA AND TUNISIA

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The sedimentology and tectonics and their relationship of the Paleozoic series that fill the Ghadames basin and its northern extension consisting of the Jefarah basin in Libya and Tunisia was studied. These formations belong to the Gondwana cycle and are typically interpreted as being deposited in a cratonic basin truncated by the Hercynian unconformity. This study is based on wells. The stratigraphic correlation between the wells is based on the definition of second order cycles. This allowed to produce isopach maps of facies distributions and to reconstruct the paleogeography of the different stratigraphic units. These data allow to address the nature of the deformation and also clarifies the behavior of active high regional areas during the Palaeozoic. The Paleozoic succession in the Ghadames and Jefarah basins can be divided in to five first order sequences, bounded by major tectonic unconformities with sequence duration of 4070 Ma. Within these five sequences eighteen second order sequences (1040 Ma) were differentiated, describing Sequence Boundaries (SB), Maximum Flooding Surfaces (MFS) and sedimentological characteristics.

HYPERSPECTRAL IMAGING FOR HIGH RESOLUTION, NON-DESTRUCTIVE AND FAST ANALYSIS OF SEDIMENT CORES: APPLICATION TO LAKE LE BOURGET AND BLACK SEA SEDIMENT CORES

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Sedimentary archives are used to infer past climate and environment thanks to their physical and chemical properties. Sampling methods (millimetric or centimetric) and routine analysis are time and material consuming. The use of some specific spectroscopic methods and data analysis, allow to develop and perform some robust methods capable of (i) fast high resolution (ii) performed at low costs (iii) non-destructive and (iv) monitor concentration variations of major sediment compounds. X-ray fluorescence spectroscopy is one of these techniques, but it is able to detect just mineral geochemistrys. Whereas hyperspectral imaging (VNIR 400-1000 nm, SWIR 1000-2500 nm) allow, behind each voxel (a pixel with several wavelengths), to define spectral fingerprint of organic or mineral chemical compounds.

This type of data can be analyzed by statistical techniques. Many (pseudo-) univariate coefficients are available for the quantification of some molecules (RABD845 for BPhe a, RABD660-670 for chlr-a and chlorins). But in this study we choose to applied multivariate methods that take into account all spectra variations. To achieve such study we can use technic that usually applied in classical spectroscopy or for satellite data that can be unsupervised or supervised. For unsupervised techniques, without any prior knowledge of the sample, exploratory algorithms are used to determine groups in the data. Then, these groups can be interpreted with the comparison to other analytical methods. It is possible to find pure signal that corresponds to one or several organic or mineral sedimentary compounds by (i) endmembers techniques, (ii) spectral unmixing, or (iii) clustering. For supervised techniques, we can use the knowledge of sample chemical and physical properties to create prediction models, then it is possible to observe variations of a specific property along the core. To develop qualitative and quantitative model for focused spectral properties we can applied classification and regression techniques. They allow to discriminate spectral domains or some wavelengths for some interest property.

In the present study, Lake Le Bourget (Savoie, France) and Black Sea (Northwest margin) sediment cores are used. From this two different environmental systems we could create and test several prediction models. The high-resolution acquisition is done with two hyperspectral cameras: VNIR (400-1000 nm) and SWIR (1000-2500 nm) with spatial resolution of several dozen micrometers. Both sensors are well designed to create predictive models for either physical or chemical properties. In order to improve prediction models and make them more robust, we can pair these two cameras and add XRF core scanner data. For the black sea sediment, we use unsupervised techniques to determine groups and define interesting spatial areas to take samples for analytic analysis. Whereas for the Lake le Bourget sediment, several previous studies allow us to have many available data, thus supervised techniques are used to observe along core variations. For some properties, we could try to use models of the Lake Le Bourget in the Black Sea data, for example if we create a grain-size model, chemical elements ratio or organic compounds.

SEQUENCE-STRATIGRAPHIC CONTROLS OVER $\Delta^{13}C_{CARB}$ VARIABILITY AND CONODONT DISTRIBUTION IN THE HOMERIAN (SILURIAN) OF THE MIDLAND PLATFORM, ENGLAND

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Although spatial heterogeneity of $\delta^{13}C$ values in fossil and modern carbonate platforms is widely recognized, the factors driving this heterogeneity have not been clearly identified. The previously established sequence stratigraphic framework developed for the Homerian (Silurian) of the Midland Platform allows for the documentation of fine-scale lateral variability of carbon isotope values and conodont distribution throughout the late Homerian (Mulde) carbon isotope excursion. We have used microfacies analysis to reconstruct hydrodynamic conditions and light availability across a palaeobathymetric gradient between coeval sections reflecting a transition from shallow (Dudley area, West Midlands) to somewhat deeper (Malvern and Suckley hills, Herefordshire) parts of the platform. Consistent differences between $\delta^{13}C$ peaks in coeval strata are associated with contrasting relative sea-level trends observed between the two regions: $\delta^{13}C_{carb}$ values increase in progradational (upward shallowing) parasequence sets and decrease in coeval retrogradational (upward deepening) parasequence sets, resulting in different positions of the maximum isotopic values between regions. This diachroneity correlates with the rate of carbonate production between the shallower and deeper parts of the platform. Moreover, the high-resolution sequence-stratigraphic framework further allows us to quantify the effect of facies shifts on faunal distribution in a section. We divided the sections into bins corresponding to systems tracts, lithostratigraphy (proxy for facies), and depositional sequences (proxy for temporal change). Conodont α and γ diversity and turnover are compared between the bins of these three binning systems, revealing that turnover between lithostratigraphic units is higher than between depositional sequences. This approach can be applied to fossil distribution at the section to basin scale and quantify the relative offset in the appearance of index taxa, and thus apparent diachroneity, arising from the lateral distribution of facies.

REGIONAL SEISMIC CHARACTERISATION OF THE OIL SEEPING PROVINCE IN THE LOWER CONGO BASIN

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The space-borne imagery provides a significant means to locate and quantify active oil seeps in the marine environment. Despite most of continental margins are imaged with seismic data, the geophysical characterisation of oil seeps sites remains under-documented. The analysis of a large amount of overlapping satellite images revealed an abundant volume of 4400m^3 of oil naturally reaching the sea surface, expelled from more than a hundred seep sites trough the Lower Congo Basin. The combination with seismic datasets greatly improves the identification of the origin of the seeping areas on the seafloor and the associated hydrocarbon plumbing system. The active seepage area is restricted to the distal province of the basin, characterised by strong compression/shortening due to the post-salt super-sequence gliding over the thick Aptian salt décollemment level, creating pervasive salt napes and squeezed diapirs. The oil seeps are mainly located at the rim of diapirs, suggesting that thermogenic fluids migrate along salt walls and diapirs flanks. In addition to a structural control by salt, we show that most oil seep sites are spread at the edges of the minibasins that record the highest accumulation rates. Salt tectonic processes including the growth of diapirs and the development of interspersed mini-basins are producing an ensemble mecanisms triggering active fluid seepage: (1) lateral gradient of pressure in minibasins, (2) creation of a bypass system through salt tectonic fault network (3) increasing production of hydrocarbons in mini-basins series with sediment overloading and (4) a tilting of the coarser Miocene series that acts as efficient stratigraphic drains towards the seafloor. The seafloor signature of oil seeps mostly corresponds to submarine mounds or complex-shape and irregular pockmarks surrounded by hummocky-like small positive reliefs. Conversely, the large occurrence of conical shape pockmarks in mini-basins is likely associated to biogenic methane or pore water related escape features. Oil-supplying pockmarks are associated with positive seafloor amplitude anomalies and linked with vertical high-amplitude pipes rooted on the Bottom Simulating Reflection. Hummocky features surrounding the complex pockmark domains are interpreted as meter-scale seafloor asphalt mounds associated with the biodegradation of heavy oils as already seen on dives realised on similar facies. Sub-bottom profiler sections show that asphalt mounds are linked by a fault network to buried high amplitude patches. Based on the definition of those characteristics (seafloor mounds, complex shape and irregular pockmarks, positive seafloor amplitude anomalies, high amplitude vertical pipes), we identified on seismic data a series of potential seeping sites. Barely half of potential oil seep sites identified on seismic datasets are accordingly associated with recurrent of slicks at the surface. The remaining anomalies array could either be associated with gasdominated or dormant seep sites.

DETAILED SEISMIC CHARACTERISATION OF AN ACTIVE THERMOGENIC OIL SEEP IN THE LOWER CONGO BASIN

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The identification of recurrent oil slicks at the sea surface highlights thermogenic hydrocarbon seeps in the deep offshore province of the Lower Congo Basin. The hydrodynamic conditions were quantified using a current profiler trough the water column in order to quantify the probable lateral deflection and to link sea surface manifestations with seafloor features. We focused our observations at a specific oil seep site that benefits from a large collection of seafloor and subsurface geophysical datasets which enables the identification of geophysical features associated with natural thermogenic seep sites. In the studied area, salt tectonics controls the location of oil seeps by fracturing the overburden, creating a thermal anomaly of the base of the gas hydrate stability zone (BGHSZ) that concentrates hydrocarbon migration towards the crest of the diapir. The salt-related faulting of the overburden creates a mini-graben that forms a complex-shaped feature on the seafloor corresponding to a main depression area surrounded by hummocky-like seafloor mounds within which develop a cluster of heterometric pockmarks. These are characterised by positive seafloor amplitude anomalies and seafloor-reaching enhanced reflections on the sub-bottom profiler (SBP). They are also linked with vertical high-amplitude pipes rooted on the Bottom Simulating Reflection that may reveal the presence of focused fluid flow conduits guiding fluids upwards. In peripheral areas, the sea floor mounds are linked by shallow faults to buried enhanced reflections on the sub-bottom profiler sections. Restricted-size seafloor mounds interpreted as seafloor asphalt storages are connected by shallow faults to buried high amplitudes on the SBP sections interpreted as carbonate slabs. The spatial concurrence of severe biodegradation areas with a thickening of the sediment thickness above carbonate concretion series involve a moderate/dispersed hydrocarbon flow in peripheral areas. The focused depression fluid conduits are emplaced in close proximity to the dispersive seepage area, suggesting a rapid lateral changes in the seeping mechanism and a strong decrease of the hydrocarbon flow. The migration pathway of seeping fluids is affected by two consistent and sub-parallel reflections with negative polarity. The first is interpreted as the methane-related BGHSZ, the second as corresponding to the base of a thermogenic BGHSZ produced by a mixture of heavier gas. From the combination of available dataset, we propose a model for complex pockmark formation associated with deep thermogenic fluids migration.

RECONSIDERING THE FORMATION OF HUMMOCKY CROSS-STRATIFICATION

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For the past three to four decades, the hydrodynamics and facies variability of shallow marine storm deposits (tempestites) have been the subject of intense debate, with particular focus on the formative processes and environmental significance of hummocky cross-stratification (HCS). Based on its prevalence in many ancient wave-dominated facies tracts, HCS is commonly used as a diagnostic element of storm-derived deposition in the offshore transition to lower shoreface zone, and the structure has been reported from countless outcrop and core studies. Nevertheless, the genesis of HCS sandstones and many other types of tempestites remains uncertain.

Most tempestite facies models envisage storm wave-generated oscillations to be superimposed by offshore-directed geostrophic relaxation flows formed in response to coastal setup. Thus, HCS is generally considered to represent the combined migration and aggradation of relatively stable threedimensional dunes, formed by strong oscillatory sheet flows or oscillatory-dominated combined-flows between the mean fairweather and storm wave bases. However, only few studies report high-resolution proximal–distal facies relationships across large-scale basin transects, and detailed intra-facies variability probably forms a relatively overlooked part of many tempestites. This inhibits solid hydrodynamic interpretations of their various stratification and architectural types. Recent studies have brought to attention the importance of combined storm-induced oceanographic currents and hyperpycnal river discharge in prodeltaic settings, with the resulting implementation of HCS and fluid mud deposits in several hyperpycnite facies models. Along with a number of accounts of tempestites exhibiting sedimentary structures indicative of tidal currents and inherent flow instabilities, these findings call for a refinement of tempestite facies models.

The Lower Cretaceous Rurikfjellet Formation in Spitsbergen, Svalbard, exhibits a spectacular variety of tempestites and storm-induced hyperpycnites in a siliciclastic ramp succession of prodeltaic offshore to lower shoreface facies associations. The formation is exposed at many localities across Spitsbergen, and along with a number of drill cores, this permits confident reconstruction of near-basin-scale proximal–distal facies and hydrodynamic relationships. Detailed sedimentological investigations were performed on > 930 tempestites across the entire transect of the outcrop belt, including variable configurations of hummocky sandstone bodies, tide-influenced tempestites, wave-modified hyperpycnites and fluid mud deposits. We demonstrate how the HCS sandstones can be attributed to a polygenetic origin, and how their facies architectural modes are controlled by the degree of flow pulsation and depositional instabilities. A conceptual facies model applicable to similar storm-dominated successions is proposed, with important implications for the formation of HCS

ACOUSTIC RESPONSE OF SEAFLOORS COLONIZED BY FRAMEWORK ORGANISMS

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Corals, sponges, algae and bryozoa can grow as solid, calcified frameworks to significant heights above the seafloor in many areas of the ocean. High-frequency sonar signals for seafloor imaging, classification and depth-sounding systems interact with these raised features before insonifying the actual sediment/ rock substrates below. This two-stage insonification can mislead the systems' results.

Using examples of cold-water corals, a new form of analysis that simulates the sonar signals as wavefronts is tested. The goal is to refine our interpretations of acoustic response of organism cover and substrate type. Colonies of Lophelia in early-and mature-stages, and of 'bushy' and 'fan' shapes are simulated using L-systems and layouts from the 3D printing and medical industries. The models are based on video imagings of in situ growths as well as detailed 3D scannings of coral segments.

A virtual insonification is applied to the structures, with the physics based on the eikonal function, not raypath analysis. The modelled acoustic returns at different incident angles are collected and compared to the sonar response rules that are commonly used for seafloor mapping. The methods go beyond most current methods which characterize backscatter using statistical surface roughness and volume heterogeneity, or which use a generalized response to pulse dimensions. They are able to deal with many different arrangements and types of the colonies and their substrates, including sediment matrix and the derived biodetritus.

TRANSIENT COOLING EPISODES DURING CRETACEOUS OCEANIC ANOXIC EVENTS

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Palaeoclimatic reconstructions based on the organic geochemical proxy TEX86 suggest that extreme Cretaceous temperatures were achieved during the two major Oceanic Anoxic Events of the Period, namely the early Aptian Selli Event (OAE 1a) and the Cenomanian–Turonian boundary Bonarelli Event (OAE 2). Under these extreme environmental conditions, two feedback mechanisms to reduce temperature by drawing down atmospheric carbon dioxide are likely to have operated, possibly offset by continued input of this greenhouse gas from the development of submarine or subaerial Large Igneous Provinces (LIPs). The first of these mechanisms is organic-carbon burial, the hallmark of OAEs; the second is silicate weathering, for which there is evidence in the form of calcium and lithium isotopes in pelagic and platform carbonates. Geochemical profiles through sections recording OAE 1a and OAE 2 both show evidence for multiple transient drops in temperature recorded by oxygen-isotope data in pelagic facies and TEX86 values from organic-rich shales. More subtle evidence for cooling is provided by the stratigraphic distribution of redox-sensitive trace elements in organic-lean carbonates that record seawater values during OAEs. Against a background of global drawdown of such geochemical species as Co, Cr, Cu, Fe, Mo, Ni, U, V, Zn that can be readily fixed into marine organic matter and/or sulphides, cooler ocean waters carrying more dissolved oxygen allowed the transient build-up of these elements when continually supplied by basalt–seawater interaction: a phenomenon clearly illustrated by osmium-and strontium-isotope stratigraphy in multiple sections across the globe.

HUMAN SOCIETIES BEGAN TO PLAY A SIGNIFICANT ROLE IN GLOBAL SEDIMENT TRANSFERS 3000 YEARS AGO

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Increases in soil erosion around the world cause soil degradation and compromise freshwater ecosystem services. However, global patterns of soil erosion and fluvial sediment transfer attributable to anthropogenic activities are poorly understood (c.f. PAGES-GloSS*). Lake sediments can record the rates at which matter is transported from watersheds to inland sediment basins. In addition, sediment records provide a highly informative perspective on how allochthonous loading is affected by hydrometerological and land surface characteristics over long-term time scales. Here, we reconstruct centennial to millennial changes in sediment fluxes (bulk and mineral fractions) from 631 lakes sediment archives distributed across six continents using both modeling (Revised Universal Soil Loss Equation RUSLE) and empirical data analyses (^{14}C, sediment density, and elemental analysis of lacustrine sediment cores). In addition, cores archived at the National Lacustrine Core Facility (LacCore, USA) were analysed at INRS, Canada, using tomodensitometry (computed tomography/CT scans) and micro-Xrady fluorescence (XRF). Our work identifies the hotspots and the timing of changes in soil erosion during the Anthropocene, starting 3000 years ago. Human activities, i.e., deforestation and increase in cropland, were identified as key environmental drivers of these changes.

*PAGES-GloSS: Past Global Change – Global Soil and Sediment transfers in the Anthropocene

BENEFITS OF FORWARD STRATIGRAPHIC MODELING IN PETROLEUM EXPLORATION: THE EXAMPLE OF OFFSHORE NL, CANADA

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In Petroleum Exploration, understanding the lithological and stratigraphic basin architecture is a key component of a successful resource assessment. We here propose a constrained 4D stratigraphic model to better assess lithology variations and the exploration risk in an integrated exploration workflows. This workflow is conducted on the underexplored Orphan / Flemish basins, located offshore Newfoundland, Canada.

The initial geological and geophysical work consists in a well and seismic sequence stratigraphic analysis. It aims at understanding and refining the sequence stratigraphic framework of the basin. Interpreted paleoenvironments are firstly defined on 2D seismic sections. This stratigraphic / geomorphologic framework is then transposed to the whole study area using the complete seismic and well dataset to create conceptual Gross Depositional Environment (GDE) maps per main stratigraphic units.

Ultimately, the G&G interpretation helps to constrain a numerical forward stratigraphic model. The conceptual GDE maps, and more specifically their estimations on paleobathymetry, sedimentary source dynamics, pathways and sedimentary object styles, are dynamically tested using the 4D forward stratigraphic modelling tool DionisosFlowTM. This model, which takes into account the interplay between sediment supply, transport and accommodation change, allows the paleoenvironment interpretations to be tested. Eventually, the model provides a geocube with various environmental properties such as lithologies (volume of sand and shale) but also water energy; bathymetry, etc.

From the geocube, facies are interpreted as a function of their environmental properties allowing lateral and vertical extension of main sediment packages and geobodies to be recognized. Based on this exhaustive G&G analysis a reliable 3D stratigraphic grid is generated, allowing the following:

- An optimal outline of the petroleum play definition: the defined plays are based on 4D (spatial and temporal) distribution of main organic-prone sediments, reservoir and seal with respect to the stratigraphic framework (regression/transgression trend).
- A detailed lithological input within the 3D petroleum system model skeleton for further hydrocarbon generation/expulsion/migration & entrapment modelling.
- A better assessment of the geological risk (Common Risk Segment mapping), by considering reservoir/seal presence and effectiveness. Risks are evaluated via the Sand and Shale distribution in the 3D stratigraphic model in terms of Net thickness, together with the presence and thickness of continuous beds.

THE TECTONO-SEQUENCE AND DEPOSITIONAL ARCHITECTURE OF THE RIFT-RELATED WENCHANG FORMATION IN THE LUFENG DEPRESSION, PEARL RIVER MOUTH BASIN, CHINA

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Different sequences types were formed during different stages due to the tectonic variations and sediment supply changes in the rift-related Wenchang Formation. Based on the cores, wire logging and 3D seismic data, sequence stratigraphy, depositional systems and control of the sequence as well as the depositional architecture are studied. Three lacustrine sequences types were formed: 1) the early syn-rift sequence (SQ1) developed fan-delta and shallow lacustrine deposits; 2) the rift climax sequence (SQ2) contains the early rift climax systems tract and middle-late rift climax systems tracts. The early rift climax systems tract primarily developed braided-delta and shallow lacustrine deposits, while the middle-late rift climax systems tract predominantly developed semi-deep to deep lacustrine deposits; 3) the late syn-rift sequence (SQ3) developed braided-delta and shallow lacustrine deposits. Tectonics is the primary control of the early syn-rift sequence and rift climax sequence; the long-term syn-depositional fault formed the transfer zones and slope break zones. As the zones for sediment entry into the basin, three types of transfer zones were distinguished, including the synthetic approaching transferzone, strike ramp and conjugate collateral transfer zones. Three types of slope break zones were also recognized, including the fault scarp zones controlling fan-deltas and nearshore subaqueous fans development, fault terrace scrap zone controlling low-stand fan-deltas development, and antithetic fault terrace dip-slope zone controlling braided-deltas development. In the late syn-rift sequence, sediment supply primarily controlled the sequence stacking patterns. In the transgressive systems tracts of SQ3, the southern dip slope developed retrogradational parasequence sets due to the weak sediment supply of the Huilu low uplift, while westward aggradational-progradational parasequence sets were developed along the long axis due to the strong sediment supply of the Lufeng eastern low uplift.

THE DISTRIBUTION PATTERN OF FAN DELTA CONTROLLED BY SOURCE-TO-SINK SYSTEM OF JURASSIC IN THE CHEPAIZI AREA, JUNGGAR BASIN, CHINA

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The characteristics and distribution pattern of fan delta in the steep slope of lacustrine basin is significant for their hydrocarbon exploration. Seismic reflection, logging, and core data were used to investigate the source-to-Sink system of Jurassic strata in Chepaizi area, then try to make their relationship with distribution pattern of fan delta clear. Three incised valley systems develop in the research area including incised valley system of single main channel, incised valley system of multi branched channels, and incised valley system of compound channels. The development of fault slope break zones in Chepaizi area controlled by thrusting of Zaire Mountain. Multiple fan deltas with different scales distribute below the slope break. Incised denudation areas around incised valleies are the main sediment supply areas of fan delta. The types and scales of fan deltas are dominated by different incised valley systems. The source area of compound valleys system is the biggest, which supply the largest amount of sediments and the sediment transport with short distance. Thus, the scale of fan deltas in this system is biggest in which the sediment performance sub angular and poor sorting. The medium source area of multi branched channels system which supply the medium amount of sediments with transporting distance similar as compound valleys system, formed the fan delta with medium scale. The source area of single main channel system is the minimum, which supply a small amount of sediments. The channel is the longest and widest in this area. Only single fan delta deposit under the slope break zone with the minimum scale. However, the sediment is mainly well-sorted medium-coarse sandstone with. In conclusion, the study areas can be divided into three source-to-Sink systems “single main channel, long distance transportation, and single fan delta” system; “multi branched channels, short distance transportation, and medium flaky fan delta” system, and “compound channels, short distance transportation, and flaky fan delta” system.

CARBONATE PLATFORM CRISIS IN THE CARNIAN (LATE TRIASSIC) OF HANWANG (SICHUAN BASIN, SOUTH CHINA): INSIGHTS FROM NEW BIOSTRATIGRAPHIC AND STABLE ISOTOPE DATA

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During the Carnian the Hanwang area, in the northwestern Sichuan Basin (South China), was characterized by shallow water carbonate sedimentation that underwent an abrupt demise associated to a sudden input of terrigenous material. This major facies change was so far considered to be the expression of the onset of the Carnian Pluvial Episode, a most remarkable environmental crisis in Late Triassic that is well recognized in northwestern Tethys margins and coinciding with a major global perturbation of the carbon isotope record. However, the lack of detailed biostratigraphic constraints have so far prevented a precise dating of the carbonate platform demise in western Sichuan Basin.

In this work, the Qingyan Gou (QYG) and Guanyin Ya (GYY) sections cropping out in Hanwang were investigated for their facies and microfacies, stable carbon isotopes of carbonate and biostratigraphy (ammonoids and conodonts). Facies analysis shows a marine transgression from inner ramp oolitic shoal to middle ramp siliceous sponge mound, then overlain by shale and calcareous siltstone with interbedded silty mudstones. Refined biostratigraphic data from QYG and GYY section imply that the demise of sponge mounds is Late Tuvalian in age. This is inferred from the occurrence of ammonoids as *Discotropites* sp., *Thisbites* sp. and common Juvavitids in the shales above the sponge mounds, and by the occurrence of conodonts *Paragondolella noah*, *Hayashiella tuvalica*, *Carnepigondolella orchardi* and *C. zoae* below and within the sponge mounds.

Carbonate carbon and oxygen isotopes were analyzed on brachiopods, microbial grains and bulk matrix from QYG section. A negative carbon isotope perturbation was found in the bulk matrix immediately below the sponge mounds demise. This excursion, however, was not found when isotope analyses on brachiopod shells were only considered, therefore the negative shift highlighted in the bulk carbonate was interpreted as related to diagenesis.

In conclusion, given the Late Tuvalian age attributed to the demise of the sponge mounds, and the absence of a carbon isotopic excursion, we infer that the carbonate platform crisis and strong terrigenous input in Hanwang cannot be related to the Julian onset of the CPE. These environmental changes and the facies deepening trend could be rather due to accelerating subsidence rates of a foreland basin developed in connection to the Indosinian orogenesis. Pollen assemblages in the shale and calcareous siltstone suggest humid conditions in the area. Therefore, climate and an increased siliciclastic input, could have also played a role in causing the carbonate platform demise.

DEVELOPMENT CHARACTERISTICS AND EXPLORATION POTENTIAL OF "MULTI-STAGE & MULTI-ROW" REEF RESERVOIR IN CHANGXING FORMATION OF PUGUANG EXPLORATION AREA

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Lithophysical paleogeographic research is the basis of marine basin exploration, and every change in understanding will greatly advance the exploration progress. Based on drilling, outcrop and seismic data, this paper argues that the Changxing Formation in the Sichuan Basin is controlled by the sedimentary differentiation, with the gentle slope platform in the early stage and the rim platform in the late stage. The distribution pattern of the reef flat reservoir is characterized by vertical staging and horizontal zoning.

According to the analysis of 14 outcrops and 26 wells, the regional lithofacies palaeogeography is considered. The Late Permian sediments in the Sichuan Basin are inherited and developed in the unconformity of the Maokou Formation. Under the control of paleo-dominance, the early stage of Changxing Formation is the slow slope, and the late stage of Changxing Formation is the rim platform. The reef reservoir of Changxing Formation is characterized by multi-stage overlap in the vertical and striped distribution in the horizontal.

According to the cycle comparison and combined with the seismic sequence calibration, considering the middle-lower part of the stable development of thin muddy uranium limestone as the marker layer, the Changxing Formation of Puguang area can be divided into two parts. Among them, the upper part of the Changxing Formation develops gentle slope reefs; the lower part develops platform edge reefs, platform internal reefs and slope patch reefs. Combined with the drilled reefs, the "two-stage and two-row" reef development model of the Changxing Formation is established.

Based on the new method and new 3D seismic data acquisition of the northern part of Puguang area in 2016, the two-stage reefs of Changxing Formation in the northern part of Puguang exploration area were described by using the technical method of strata-fixed lattice, well-seismic construction model and faciescontrolled reservoir describe. A total of 5 gentle slope reefs, 5 platform edge reefs, 4 platform internal reefs, 9 slope patch reefs, and 4 debris beaches are identified. The two-stage reefs numbers are 27 and the area of reefs is 118.0 km^2. The thickness of the reef beach reservoir predicted by the post-stack impedance inversion is about 20-180 m, and the trap resource size about 778 x 108 m^3. Three prospecting wells are deployed according to the rule of priority evaluating platform edge reefs, steady progressing reef back beach, exploring gentle slope reefs.

The building of the "multi-stage and multi-row" development model of the reef beach in Changxing Formation of Sichuan Basin has expanded the exploration space and field of Changxing Formation in Puguang area and even in Sichuan Basin.

CLIMATIC WARMING ACROSS THE PERMIAN-TRIASSIC BOUNDARY – NEW EVIDENCE FROM ARMENIA

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Oxygen isotope records measured on conodonts from Armenian Permian-Triassic boundary (PTB) sections confirm earlier published oxygen isotope patterns from South Section (e.g. Meishan GSSP). Late Permian (Changhsingian) temperatures in the Chanakhchi (formerly Sovetachen) section are on average 28 ± 0.9°C (1σ, n=30). Well comparable temperatures calculated from both hindeoid and gondolellid conodonts suggest that both taxa lived in comparable parts of the water column at similar water temperatures. Since temperatures of around 28°C are well conceivable with tropical carbonate environments, we argue that the reconstructed temperatures represent upper water column temperatures. Temperatures increase by a maximum of 10°C within the 14 cm thick boundary clay and reach 36 to 38°C below microbial limestones and thus before the PTB. Griesbachian temperatures are on average 34 ± 1.7°C (1σ, n=17) while temperatures during the early Dienerian are 38 ± 0.9°C (1σ, n=9). Late Permian and Early Triassic temperatures reconstructed in the Vedi 2 section are on average 30 ± 0.8°C (1σ, n=12) and 38 ± 0.6°C (1σ, n=5), respectively. Thus, sea water temperatures increased by 10°C in the Chanakhchi and 8°C in the Vedi II section.

Oxygen isotope records measured on conodonts from Iranian (n=2) and South Chinese (n= 5) sections all indicate comparable warming across the PTB. Further, Oxygen isotopes measured by gas isotope ratio mass spectrometry (GIRMS) have been confirmed by analysis of individual conodonts using secondary ion mass spectrometry (SIMS). For example, the temperature increase in the Iranian sections is around 7 to 10°C with reconstructed absolute temperatures being well comparable to temperatures measured in Armenian sections. Warming reconstructed in the Chinese sections is between 6 and 11°C. In all studied sections from South China, Early Triassic temperatures are between 34 and 38°C and do not show any dependence on palaeolatitude or depositional environment. However, Late Permian oxygen isotope values from the Meishan and Shangsi sections are higher in comparison to time-equivalent oxygen isotope values from other sections in South China, Iran or Armenia suggesting cooler Late Permian temperatures in these areas. In summary, warming across the PTB is documented in 9 sections from different palaeogeographic areas and occurred over a maximum interval of 200 ka.

The negative shifts in the oxygen isotope ratios and thus climate warming coincide with the well documented negative excursion in carbon isotopes. Although the negative carbon isotope excursion started slightly earlier, changes in the global carbon cycle likely triggered by Siberian trap volcanism and related thermal metamorphism of organic carbon rich sediments were interpreted to have injected large amounts of CO_2 and CH_4 into the ocean-atmosphere system culminating in global climate warming. Climate warming started with the onset of extinction at 252.30 Ma which seems to indicate that the catastrophic temperature rise cannot be a major trigger of the extinction. However, taking into account statistical analysis of fossil occurrences (Signor-Lipps effect), the catastrophic extinction occurred over a maximum interval of 200 ka, corresponding to the interval of climate warming.

SEISMIC STRATIGRAPHY OF THE DIEPPE-HAMPSHIRE BASIN (EASTERN ENGLISH CHANNEL)

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The Dieppe-Hampshire Basin, located in the eastern English Channel, between SE of England and the French Coast, developed within the Anglo-Paris Basin during the Cenozoic, a period of overall tectonic inversion, in response to the opening of the North Atlantic Ocean and Pyrenean-Alpine deformation episodes. Former studies have given a first idea of the stratigraphy of the basin, but the detailed stratigraphic framework of the offshore part of the Dieppe-Hampshire Basin still remains poorly constrained. These previous studies have shown ages ranging from Thanetian to Bartonian in the southern part of the basin. However, there are still gaps in the seismic stratigraphy and the sequence stratigraphy knowledge in this area.

Recent very high resolution seismic data (Sparker), acquired during oceanographic cruises "TREMOR" (R/V "Côtes de la Manche", 2014) and "TREMOR 2" (R/V "Thalia", 2017), have allowed to develop a fine-scale stratigraphic description of the southern Dieppe-Hampshire Basin. Seismic stratigraphic and sequence stratigraphic criteria (seismic facies analysis and identification of reflector terminations) led to the characterization of many seismic units and remarkable surfaces within the preserved Cenozoic series, that represent several hundred meters. This unprecedented high resolution seismic stratigraphy has been compared with existing samples and new coring samples, acquired during the "TREMOR 2" campaign, and we propose a chronostratigraphic timing of the identified seismic units. The analysis of the directions of progradation has also been helpful for a better understanding of the paleogeography.

Furthermore, by comparing this new seismic stratigraphy to that of adjacent Cenozoic basins (Paris Basin, SE of England, Belgian Basin), we integrated its evolution into the Paleogene geological framework of the Anglo-Paris Basin. Thereby, we propose a stratigraphic model for the Paleogene of the Dieppe-Hampshire Basin and we discuss it in terms of sea level changes and high wavelength deformations caused by structural events along plate borders.

SEDIMENTARY ARCHITECTURE OF A PLIOCENE RIVER-DOMINATED DELTA FLOWING INTO THE SEMI-ISOLATED DACIAN BASIN (ROMANIA)

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Facies models of lacustrine deltas commonly differ from facies models of deltas evolving in the open ocean. Deltaic processes are differently registered in (semi-)isolated basins and therefore these deltas build peculiar sedimentary architectures. During the Pliocene, the Dacian Basin constituted an embayment of the Black Sea. This brackish semi-isolated basin was filled in by a delta flowing southwards along the uplifting Eastern Carpathians. The deltaic sediments currently crop out along the continuous, well-exposed and fossil-rich Slănicul de Buzău section in Romania. The studied 835 m thick Pliocene deltaic interval marks the transition from distal shelf sediments with brackish-water fauna up to shallow fluvial sediments with fresh-water fauna. The interval exposes around 70, clearly-expressed, decimeter-scale, regressive parasequences. The parasequences regress from distal pro-delta clays to proximal delta-front or delta-top sands, which commonly register small-scale cross stratifications (350 cm sets) and an enrichment in organic material, bioturbation, endemic brackish and fresh-water mollusk faunas. The parasequences are typically topped by sharp-based, fossil-rich sand bodies with small-scale cross stratifications (5-20 cm sets). These high frequency parasequences combine into several, 300 meters thick, regressive sequences. The sequences are composed of thick clay-dominated parasequences at the base, which progressively become thin sand-dominated towards the tops of the larger-scale sequences.

The deltaic system was interpreted as a river-dominated delta. Because of the strong river influence of this delta prograding on a protected coast, sediments experienced minor sediment redistribution, resulting in an enrichment in organic material, bioturbation and fossils. Sediments were transported towards the basin by gravity currents on a low-gradient slope, causing a multiplication of terminal distributary channels, covering a wide depositional area. Due to the low salinity of the basin, sediments were also frequently transported by hyperpycnal plumes. The deltaic succession, being deposited in a shallow basin with restricted accommodation space, formed numerous thin parasequences, regressing up to sharp-based delta-front and delta-top sands. The studied delta was interpreted as prograding on a shallow, low-gradient and protected slope, into the brackish-water semi-isolated Dacian Basin.

The section has a robust magnetostratigraphic time frame, which provides the opportunity to compare the observed sedimentary cyclicity with the amplitude and the frequency of various climatic cycles. The preliminary results suggest an independent behavior of the regressive parasequences, whose frequency outnumbers the precession cycles. This suggests that climate forcing had a limited influence at the timescale of delta-lobes switching. On the larger scale, the system recorded regressive sequences, separated by long periods of decrease in sand input. These relative water-level increases could imply longer period astronomical forcing through eccentricity cycles. The Pliocene Dacian Basin provided an unusual geomorphological setting, where the studied river-dominated delta shaped a peculiar sedimentary architecture. The interactions between the features of the basin and the different sedimentary processes are still indistinguishable. The variabilities of the facies models in atypical basins require further research to better understand the triggers of these unique depositional systems, in order to propose new classifications for delta prograding in (semi-) isolated basins.

A LATE QUATERNARY CARBONATE ROUTINE SYSTEM: THE GLORIEUSES PLATFORM AND ADJACENT BASIN (SW INDIAN OCEAN)

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Since the past ten years, a large amount of Source-to-Sink studies aimed to unravel the tectonic, climatic and other processes that shape the landscape from the mountains to deep ocean. Interestingly, these studies have been exclusively dedicated to siliciclastic or mixed systems, for which the connection between drainage basins, continental shelf and adjacent carbonate platforms, slope and basin environments are often well constrained.

Here we present a study focusing on a pure carbonate routine system, located in the SW Indian Ocean (Glorieuses archipelago, Mozambique Channel). Since 2011, extensive field sampling and geophysical acquisition across the carbonate platform has contributed to estimate the composition, the lateral variability, and volumes of neritic sands. Additional seismic and bathymetric surveys across the platform edge illustrate the presence of plurimetric sandy bodies deposited along the leeward platform edge, corresponding to the export of carbonate sediments under the influence of dominant wind-and current-driven processes. Highresolution seismic, bathymetry, and sediment piston cores acquired in 2014 along slope and basin adjacent to the carbonate platform led to the discovery of channel-levee complexes and turbiditic lobes, which form 250 m-thick sediment accumulations at 3400 m water depth, composed of alternating bundled calciturbidite trends and hemipelagic (aragonite-rich) layers.

Our findings clearly point out that the shedding of carbonate sands and aragonitic mud on top of small-sized carbonate platforms may contribute to feed large deep-water carbonate fans. This platform tobasin connection seems to have functioned through the last two glacial/interglacial cycles at least, and appears to have been controlled by imprints of large scale oscillations of the sea level along the platform edge, and by slope destabilization processes. This study has important consequences for our understanding of carbonate gravity processes occurring along isolated carbonate platforms, and contributes to a first attempt to quantify a carbonate sediment-routine system.

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DEGLACIAL ORIGIN OF BARRIER REEFS ALONG LOW LATITUDE MIXED-SILICICLASTIC AND CARBONATE CONTINENTAL SHELF EGDES

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Because the initial phase of barrier reef evolution is often buried under more recent phases of coralgal growth, the origins of modern barrier reefs have remained elusive. Direct observations on the nature of the substrate on top of which barrier reefs have developed are lacking, and simple questions about whether the substrate contributes to their overall linear morphology have remained unanswered.

We present here a review dedicated to late-Quaternary shelf-edge deposition in tropical mixed siliciclastic-carbonate systems which include the central Belize barrier reef, the northern extremities of the Australian Great Barrier Reef, Papua New Guinea barrier reef in the Gulf of Papua, and the New Caledonia barrier reef, all of which thrive on the edge of mixed siliciclastic-carbonate continental margins. Based on the striking similarities between the shape of the modern barrier reefs and the morphologies observed along adjacent modern and past undelying coastal systems, we used modern analogs to develop a quantitative understanding of shelf edge barrier reef formation during different segments of relatively well established sealevel cycles. The onset of rapid sea-level rise during early deglaciations, when siliciclastics were deposited along newly formed coasts at up-dip positions, provided opportune time windows for coralgal communities to establish themselves on top of maximum lowstand siliciclastic coastal deposits, such as beach ridges, shoulders of river incisions, and lowstand shelf-edge deltas.

All data sets presented in this contribution focus on the relative importance of eustatic sea level, climate changes, and tectonics to gaining a better understanding of the evolution of mixed continental margins. For a time of relatively well-established climatic and eustatic sea-level records, our observations therefore address crucial questions on sedimentary processes, responses, causes, and effects in the context of carbonate platform/reef establishment, growth, (partial) demise, and rebirth along mixed siliciclastic-carbonate margins.

CATS: A PROCESS-BASED NUMERICAL MODEL FOR TURBIDITE SYSTEMS APPLIED TO THE 1979 NICE TURBIDITY EVENT

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To reproduce the complex architecture and facies distribution of turbidite systems, IFPEN has developed an innovative process-based numerical model named CATS (Cellular Automata for Turbidite Systems).

The flow is described by its sediment-laden flow thickness, a scalar velocity computed from kinetic energy balance, and mean volumetric concentrations of the different “lithologies” defined by as many discrete classes of particles (grain size and density) as needed to describe the sedimentary system. In the flow, vertical concentration profiles are computed analytically with the Rouse number in order to take into account the different vertical distributions of coarse and fine particles.

CATS models the gravity-driven sediment-laden turbidity current and associated processes (entrainment of ambient water, erosion and deposition of different particles) over the sea-bed. The flow distribution is computed through the local algorithm of “minimization of height differences” developed first for landslides by Di Gregorio et al. (1999) and adapted for turbidity currents by Salles et al. (2007). The algorithm seeks the equilibrium of both potential and kinetic energies, to take into account both gravitational and inertial effects. This version of the model is designed for dilute low-density turbidity currents which carry sediments in suspension. Thus, sediment erosion and deposition rules have been specifically modified to consider the flow capacity to carry each sediment in suspension in addition to classical shear-stress thresholds. The model gives the evolution of the scalar flow parameters on the surface representing the sea-floor and the resulting eroded and deposited thicknesses for each lithology.

To validate this model, its application to the 1979 Nice turbidite event is presented. On October 1979, the airport new embankment collapsed into the sea and developed into a turbulent turbidity current. The current flowed downslope along the Var canyon then along the Middle Var Valley. It broke two submarine cables 3h45 and 8h after collapse respectively at 90 km and 110 km from the slide area. With these constraints, several authors have estimated velocities along the flow path. Flow behavior was reconstructed from data including diving observations, bathymetric/backscatter and side-scan sonar data, and cores. Erosive features on the middle canyon flanks constrain the flow minimum thickness to 40-50 m. Then, in the lower canyon, the flow spilled over a 70-m high terrace. Along the Valley, the flow did not overtop the Western Var Ridge but overflowed the eastern part leaving erosional scours, suggesting the flow thickness ranged between 300 and 60 m. Core data showed few cm thick fine-sand deposits in the Middle Valley, 5-9 cm thick fine-medium sand deposits in the eastern end of the Ridge and up to 50 cm of medium sand in the distal lobe. We compare the CATS simulation results against these data on both flow dynamics and deposit thickness distribution to discuss its validity.

CORAL REEF RESPONSES INFERRED FROM IMPRINTS OF DEGLACIAL SEA-LEVEL CHANGES ON CARBONATE AND MIXED CARBONATE/SILICICLASTIC PLATFORMS (SW INDIAN OCEAN)

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Millennial-scale changes in sea-level and meltwater pulses (MWPs) occurring over the last 20 kyrs have been reported from several archives worldwide, particularly from dated coral reefs. However, such eustatic markers are skewed by local vertical motions including tectonics and isostatic adjustments. While statistical overview of far-field reconstructions trend to underestimate the catastrophic short-term events, simulations of regional isostasy increasingly require geological constraints to infer past eustatism from relative sea-level (RSL) records. New observations recently perfomed in the SW Indian Ocean reveal additional evidence of sea level "fingerprints" regionally preserved in different tectonic and sedimentological settings. High-resolution bathymetric and seismic data, dredge and sediment core samples were collected along the shelf edges and uppermost slopes of an isolated carbonate platform (Glorieuses Archipelago) and mixed carbonate/siliciclastic platforms (NW Madagascar and Mozambique). The various shelf edges display a succession of regionally-correlated drowned terraces on the seabed morphology and erosional surfaces buried by aggradationnal units inferred from seismic stratigraphy. The submerged (and covered) terraces at depths of -35 m, -45 m (-60 m), -80 m (-90 m) and -105 m are interpreted as wave-ravinement and abandonment surfaces. Dredging of morphologies confirms that these features are carbonate in nature and Holocene in age. These surfaces top several seismic units interpreted as backstepping transgressive parasequences. Coring of carbonate-rich upper slope stratigraphy highlight the increasing sedimentation rate during the first stage of platform flooding (after 10-12 cal kyrs BP) associated with revived production of carbonate sediments by producers nearby. The comparison with sea-level reference curves allows to identify two periods of faster sea-level rise and induced reef-drowning. The give up phases occurred between -105 m to -90 m and -80 m and -60 m, during the MWP-1A and around 13 kyrs BP respectively. The latter phase is not well-documented to date but the Tahiti curve suggests a step in sea level at equivalent depths near the onset of the Younger Dryas (YD) event. This stage ended around60 m by keep up and/or erosion phase already attributed to the YD period on the Mayotte foreslopes. The identification of aggradationnal carbonate units between -60 m and -45 m contributes to the debate on the existence of the MWP-1B. Increase in sea-level after YD allowed reefs to catch-up, thus confirming that the sea-level surge occurred but that the rate of rise was lower than previously proposed in the Barbados records. At the onset of Holocene, the flooding of the platforms, around50m in the SW Indian Ocean, caused a major change in accommodation space favoring scattering of the reef builders (isolated pinnacles) and then the final backstepping of reefal units to present high energy zones. Finally, our findings highlight the high potential of these scattered platforms to study synchronous reef responses to rapid past sea-level changes. They will be further investigated during forthcoming drilling operations to additionally document the last deglacial sea-level rise.

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IMPACT OF SALT TECTONICS ON MESOZOIC CARBONATE PLATFORM DEVELOPMENT: INSIGHTS FROM OUTCROP ANALOGUES (HIGH-ATLAS, MOROCCO)

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Carbonate platforms affected by salt tectonics form important hydrocarbon reservoirs. In an effort to gain new insights of the impact of diapirism on carbonate systems we have undertaken an integrated structural and sedimentological study of Jurassic carbonate platforms of the Moroccan High-Atlas basin. In this natural laboratory, the scale of outcrop exposure is similar in area to a large offshore seismic dataset, and field observations provide high details on the geometries and facies distributions around diapiric structures.

The Atlas intracontinental basin initiated during the Triassic, contemporaneously with Atlantic rifting. The Triassic syn-rift sequence includes thick shales and evaporite deposits accumulated in multiple tectonic sub-basins. A thick (> 5000 m) Jurassic sequence was deposited during an overall post-rift stage in a WSW-ENE shallow-marine basin open towards the NeoTethys. From the Sinemurian, sedimentation was mainly made of carbonates. However, geodynamic events linked with the evolution of the Atlantic margin produced several phases of clastic influx leading to the development of mixed systems (Toarcian and Bathonian).

During the Early Pliensbachian, an extensional tectonic event triggered syn-sedimentary diapiric movements which locally lasted until the Cretaceous. These movements were responsible for the development of narrow diapiric ridges of large extent (> 100 km), controlled by normal WSW-ESE relay faults. These ridges were separating several kilometers-wide elongated mini-basins, which subsidence was induced by salt/shale withdrawal.

Regionally, diapiric movements were discontinuous in time and space, leading to significant thickness variations within the different stratigraphic units. However, diapirism did not have any major influence on the nature and distribution of sedimentary systems at the basin scale. The impact of diapirs remained essentially localized in the immediate vicinity of these structures (km-scale), where they affected both stratigraphic geometries and facies distribution. This impact appears to be very different in oolitic and mixed ramp systems in which subtle differentiation of depositional profiles controlled progressive facies variations, or in bioconstructed carbonate systems in which diapiric movements had a major role on the location and morphology of platform margins and associated "micro-rim-basins".

In return, the geometry of the diapirs was clearly influenced by the lithology of surrounding rocks.

RECENT HYDROLOGICAL VARIABILITY OF THE MOROCCAN MIDDLE-ATLAS MOUNTAINS INFERRED FROM MICRO-SCALE SEDIMENTOLOGICAL AND GEOCHEMICAL ANALYSES OF LAKE SEDIMENTS

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The frequency and/or intensity of extreme precipitation events and droughts is expected to increase in the Mediterranean basin in the XXI century. Future adaptation to water availability in Mediterranean regions will require a precise knowledge of recent and past hydrological variability. The Moroccan MiddleAtlas Mountains are considered as the "Moroccan water tower" and contains several natural lake systems of tectono-karstic origin functioning as "pluviometer". This region suffers from scarcity of observational hydrological data required for a coherent management of water resources. In this context, the precise study of the lacustrine sedimentary infill can provide some key information about past hydrological changes. However, the hydro-sedimentary dynamics need to be fully understood before extracting relevant hydrological reconstructions. In this work, we focused on the micro-scale analysis of well-dated sedimentary deposits of Lake Azigza (32°58'N, 5°26'W, 1,470 meters a.s.l.) in the Moroccan Middle-Atlas. A combined approach based on elemental/mineralogical and geochemical measurements coupled to microfacies characterization of the sediments was conducted on the lacustrine sequences. The K-XRF signal has been related to runoffderived clay particles, streaming in small canyons present in the proximal lake catchment. Several types of microstructures, i.e. very thin laminations composed of different biological and detrital materials coming from the shoreline, were linked to increased superficial runoff during high/low lake level periods. We were therefore able to provide proxies of runoff activity and lake level changes calibrated to hydro-climate observations available for the last 50 years. Extending these interpretations to the end of the sequence, changes in hydro-sedimentary dynamics offer the possibility to reconstruct past hydrological changes since 1879 at inter-annual to decadal time-scales. Our results also highlight drastic lake level drops marked by different hydro-sedimentary dynamics since the last two decades. Recent drier conditions are unique regarding the past 134 years.

CHARACTERIZATION AND DISTRIBUTION OF EFFECTIVE SANDSTONE BODY OF FLUVIAL TIGHT GAS RESERVOIR, MEMBER 8 OF SHIHEZI FORMATION, SU6 BLOCK, ORDOS BASIN, CENTRAL CHINA

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Attracting much attention in the petroleum filed during the last decade, tight sandstone gas has presently been the focus of unconventional resource development in the global natural gas exploration of China. Until 2016, the tight sandstone gas reserves account for more than one third of natural gas reserves in the whole nation, and its annual production reach up to 1/4 of the total. Thus, tight gas reservoir has becomed the hotspot of oil and gas exploration and development in recent 20 years.

As representative of tight sand gas reservoir in China, the Sulige Gas Field in the Ordos Basin has been developed and achieved rapid progresses in recent years. Su6 block , one of the key blocks in the Sulige Gas Field develops a typical tight sandstone gas reservoir with "strong heterogeneity low porosity, low permeability ", so it is a challenge to characterize and predict the effective reservoir of the main hydrocarbon zone, He 8 member.The main objective of this paper is to establish a set of suitable ideas and techniques to characterize the effective sandstone body and predict its distribution with core, well log, producing data, so as to improve oil recovery and stable potential. Firstly, lithofacies classification, sedimentary microfacies and physical property of the reservoir were deeply studied with core measurement and log interpretation, and subsequently a set of quantitative recognition criteria of tight gas reservoir in member 8, su6 block was established. Secondly, the effective reservoir architecture, like vertical stack, lateral cutting and horizontal distribution within the high resolution sequence stratigraphy framework and the fluvial facies deposit pattern, was systematically anatomized. Finally, spatial distribution disciplinarian and quantitative characteristics of reservoir were predicted according to lithofacies, microfacies and petrophysical properties, meanwhile, the main geological controlling factor of sweet spots favorable distribution in He 8 gas reservoir, su6 block was revealed.

The result showed that although sandstone was stacked in large area indeed, the continuity and connectivity of effective sand bodies in the study area were proved to be poor, mainly distributing in point bars and channel bars. The results of this paper provided geological basis for estimating the original volume of hydrocarbon in the reservoir, making production strategy and improving development effective of the fluvial tight gas reservoir.

3D-BASIN MODELING OF TERMINAL FAN DEPOSITIONA CASE STUDY OF J BLOCK IN DA'AN OILFIELD

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The J-Block in Da'an Oilfield is located in the secondary structural belt of the Da'an-Honggang terrace in the central depression of the Songliao Basin. The transition zone of the first-order tectonic unit in the central depression and the western slope area is close to the anticline The structural shafts belong to the tectonic-lithologic reservoirs. There are two main faults and a secondary fault in the block. The fault direction is northwest and westward, and the reservoir heterogeneity is serious, which is a low porosity and low permeability reservoir. Based on the study of sedimentary model in Da'an oilfield, it is considered that this area has the characteristics of terminal fan deposition system, and the subphase environment is the middle subfacies and the distal subphase. On the basis of subdivision sedimentation unit, the sedimentary microfacies types are identified according to the characteristics of natural gamma and other logging curves, combined with the sedimentary conceptual model and the distribution of flat and microphase distribution. It is found that the sedimentary microfacies are mainly distributary channels, near the river channel overflows, far river overflows and mudflats. According to different microphase types, different parameters of variation function are selected, which are constrained by two-dimensional sedimentary microfacies. Finally, the sedimentary microfacies model is obtained. Under the constraint of sedimentary microfacies model, the pore permeability attribute is interpolated, and the attribute model of reservoir is obtained. Using random modeling method, a number of pore percolation models are established. Combined with the principle of "humancomputer interaction", Infiltration of the characteristics of the model to adjust the treatment, the final gets the required geological model. The model is validated from the four aspects: the attribute distribution of the reservoir, the model volume calculation, the crude oil geological reserve and the production dynamic fitting. The geological model can reflect the relevant properties of the reservoir, and the later numerical simulation and the remaining oil. The distribution law laid the foundation for the study.

CHRONOSTRATIGRAPHIC AND TECTONOSTRATIGRAPHIC ANALYSIS OF THE MIOCENE MOLASSE OF THE SUBALPINE MASSIFS AND SOUTH JURA (WESTERN ALPS, FRANCE). AN UPDATE

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Most of the present-day models regarding the sedimentary and tectonic evolution of foreland basins have been developed in the western Alps. The Paleogene evolution of the foreland molasse basin has also been broadly used to date the propagation of the deformation and the ultimate shortening of the Alps. If sub-basins located in the western alps foreland basin have been extensively documented (e.g., Swiss and SE-France molasse basins), the molasse-bearing synclines along the subalpine massifs, the south of the Jura massif and the eastern border of the "Bas-dauphiné" basin still remain poorly described and facies ages stays weakly dated or undated. This lack directly impacts our understanding of the timing of the successive syn-sedimentary deformation phases during the Miocene, which result from a complex interaction between tectonic, stratigraphic and lithospheric dynamics.

The aim of this multi-disciplinary study is to build an updated and integrate picture of the sedimentology, chronostratigraphy and deformation history of Molasse deposits throughout the Miocene between the subalpine massifs, the south of Jura massif and the eastern border of the "Bas-dauphiné" basin within the foreland basin. Our preliminary results show:

• numerous sedimentary sequences equivalent in age to the SE-France and "Bas-Dauphiné" molasse basin sequences have been reappraised and constrained in time between the Late Burdigalien (S2) and the Late Serravalien (S6). S2 and S3 (Langhien) sequences have been dated by using nannoplankton and strontium (e.g., chimiostratigraphy) dating. The age of sequences S4, S5, S6 was established on the basis of regional (stratigraphic) correlations.

• an Early Burdigalien age (i.e., S1sequence,20.2 Ma) from marine molasse deposits in the Royans area. Latest marine deposits from S1 are commonly located 60 km southwards (at "Crest") and 150 km northwards (at "Génissiat").

• paleo-topographical evidence has been commonly described on the field. Early Miocene deposits overlie a wide range of older sediments, ranging in age between the Mesozoic (e.g. Jurassic and Cretaceous) and the Early Cenozoic. The contacts between Miocene and older sediments are most often conformable but we found locally one evidence of unconformity. Usually, the onset of deformation in the foreland basin is attributed to the late Miocene (Tortonien); however, our evidence suggest that the deformation initiated much earlier, most probably during the Burdigalian.

Several chronostratigraphical methods are to be conducted in the frame of this study (some measurements currently in progress): $^{87}Rb/^{87}Sr$ and cosmogenic (^{10}Be) dating, biostratigraphy (nannoplankton, foraminifera), magnetostratigraphy and palynostratigraphy. This step will be of utmost interest to (i) build a robust chronostratigraphical framework, (ii) establish regional correlations using modern sequence stratigraphy concepts, (iii) reconstruct (regional) palaeogeographic maps and (iv) constrain the timing of deformation as registered in the Molasse basin. Ultimately, we aim at updating current infill models in foreland basins, both in time and space (e.g., 4D).

VERTICAL ANOMALY CLUSTERS (VACS) EVIDENCING HYDROCARBON LEAKAGE FROM MESOZOIC SOURCE ROCKS IN THE BARENTS SEA

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In this work, we present a unique kind of hydrocarbon-related high amplitude anomalies called vertical anomaly clusters (VACs). The research workflow includes seismic interpretation of the anomalies across multiple 2D seismic lines and the use of seismic attribute such as chaos, instantaneous frequency, and spectral decomposition. The VACs in the study area are reflected as zones of clustered high-amplitude reflections that are embedded within very low-amplitude, non-reservoir strata of Late Cretaceous age. On seismic sections, the VACs display variable geometries including tree, transgressive, canopy, flat and diamond-shaped anomalies, all indicating gas hosted in hemipelagic to permeable strata. Distinctive seismic fluid-markers associated with VAC in the study area include frequency shadows and push-down effects signifying that VACs are free gas in the subsurface. In the study area, gas chimneys are the primary conduits for vertical migration of the gas from Mesozoic rocks into younger Cenozoic strata. Hydrocarbon leakage in the study area is a reflection of the complex interplay of tectonics, uplift, and erosion that affected the study area in Late Cenozoic to Recent. Our work demonstrates that VACs ubiquitous and represent a new and exceptional group of direct hydrocarbon indicator that are have been classified as Class III amplitude versus offset (AVO) in similar North Atlantic basins.

3D CHARACTERIZATION AND ORIGIN OF HYDROTHERMAL PIPES IN THE VIGRID SYNCLINE, NORWEGIAN NORTH SEA

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Hydrothermal pipes are ubiquitous proofs of vertically focused fluid-flow in many petroliferous basins worldwide. Their true geometries have been observed and described from three-dimensional (3-D) seismic data in the last two decades leading to several mechanisms being proposed for their pipe formation. In this work, ten (10) hydrothermal pipes are described from 3-D seismic reflection data from the Vigrid Syncline, Vøring Basin. Our objectives are to assess the timing of pipe formation, mechanisms leading to their formation, and their impact on overburden deformation. To achieve these objectives, we have categorized the pipes based on their morphometry and associated geomorphological structures. Parameters of importance analyzed here include the height, width, slenderness ratio i.e., height/diameter (Ω) and ellipticity of the palaeo-pockmarks or mounds found at the zeniths of the pipes. On seismic profiles, the pipes include cylindrical, columnar and conical zones of disturbed reflections often inundated by high amplitude character as compared to surrounding reflections. Heights and diameters of the pipes range from c. 860 m to 2030 m and c. 1540 m to 4950 m, respectively. Estimated slender ratio for the pipes range from 0.22 to 1.32. The upper terminations of these pipes commonly coincide with palaeo pockmarks and mounds, which are parts of a Lutetian to Priabonian reflection. The pockmarks are elliptical to sub-circular in map view with surface area and ellipticity of 1.30 to 9.80 km^2 and 1.12 to 2.84 signifying a close connection between pipe formation and a high fluid expulsion process. In contrast, paleo-mounds are likely composed of extruded sediments from the pipes. In the study area, the pipes are mostly rooted within the Maastrichtian Springar and Barremian Lysing Formation. Magmatic sills interacting with the pipes are linked to an underlying sill complex at depth of 4500 to 5000 ms TWTT providing a cause-effect relationship between magmatic intrusion and pipe formation. Our work demonstrates that the interplay of magma and fluids at deeper depths led to hydraulic fracturing and localized collapse of the overlying rocks. Pipes in this study are probable secondary migration routes for hydrocarbon from deeper source rocks into the overlying sands of Nise and Lysing Formation.

BIOTIC AND ABIOTIC PROCESSES INVOLVED IN THE FORMATION OF BANDED IRON TRAVERTINE

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In Greece, several geothermal systems mainly related to the Tertiary-Quaternary magmatism and active faulting in the South Aegean Active Volcanic Arc and the back-arc regions, discharge deep hydrothermal fluids as terrestrial hot springs and submarine hydrothermal vents. In some cases, the hydrothermal fluids are highly enriched in metals and active mineralizing processes have been documented, resulting in the deposition of ore-bearing travertines. In particular, some active travertines of the northern part of Euboea Island (Greece) exhibit a unique iron enrichment up to ore grade concentrations (up to ~29 wt. %). However, the origin of this enrichment, potentially linked to the interweaving of biotic and abiotic process is not fully understood. We thus conducted a mineralogical, geochemical and microbiological analysis to address the specific depositional processes of iron in this travertine system.

The Na-Cl hydrothermal fluid is enriched in Fe and Ca, with temperatures up to 63 °C and pH ~ 6. It is interpreted as a mixture of ascending reducing hydrothermal fluids and seawater, with chloride being the dominant anion. Current carbonate precipitation is characterized by laminated to banded travertine. The bands are up to few cm thicknesses and are either Fe-rich (brownish-metallic color) or Ca-rich (orange-yellowish color). The mineralogical composition of the Fe-rich bands is mainly ferrihydrite and some aragonite whereas the Ca-rich bands encompass aragonite and calcite with some ferrihydrite and halite. SEM imaging of the iron-rich bands revealed fine scale laminae of iron-rich mineral phases (ferrihydrite) alternating with calcium-rich (aragonite) laminae at intervals of a few tens of micrometers. In order to understand the origin of this layering, we have analyzed the microbial communities of several samples, associated to this travertine system. Water covered samples were characterized by the presence of Aquificae sequences, thermophilic organisms common in hydrothermal springs. They were also enriched in ^{16}S rRNA gene sequences of organisms involved in iron cycling, in particular Zetaproteobacteria sequences related to the Mariprofundus genus. This genus is composed of iron oxidizers that are commonly identified in ferrihydrite-rich environments. Conversely, samples that were taken at the edges of the water flow (lower temperature and almost dry) lacked Aquificae sequences and were markedly enriched in cyanobacteria sequences. Zetaproteobacteria were almost completely absent of these samples.

We propose that the hot water, which determines the presence of thermotolerant to thermophilic organisms, allows the development of a specific microbial community that along with kinetics, plays an essential role in the deposition of iron oxides. Zetaproteobacteria are probably the main bio-actors facilitating the deposition of ferrihydrite. The occurrence of halite in Ca-rich bands, together with the absence of iron oxidizers in dryer environments suggest that changes in the flux of the hydrothermal fluid is likely responsible for the lamination pattern, and could be seen as a modern analog of the deposition of banded iron formation.

SELF-SIMILARITY OF INTRASALT THRUST FAULTS: LESSONS FROM OFFSHORE LEVANT BASIN AND THE DEAD SEA

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Stringers of siliciclastic material interbedded in evaporite bodies provide good internal seismic reflections in otherwise transparent seismic facies, and can offer important information about the internal salt structures and deformation. The deformation history and dynamics of the Messinian intrasalt layers in the Eastern Mediterranean Sea remain contested. Gravitational spreading, margin uplift and basin-rotation andtilting have developed a complicated interplay of thrust faulting throughout the basin. Our aim is to compare these structures from different scales and see how the understanding of small-scale thrust faults from the Dead Sea could illuminate the enigma related to the evolution of intrasalt thrust faults from the Levant Basin. To achieve this aim, we have interpreted high resolution, high quality, three dimensional seismic reflection data from the Levant Basin and used information from detailed mapping of several thrust fault systems from the Dead Sea from recently published data. The investigated thrust systems, offshore Israel have a general NW-SE orientation, and form downslope-and upslope-directed piggyback sequences with a basal detachment within the evaporite package. Secondary faulting, underthrusting and oversteepened fore thrusts and back thrusts correspond to observed outcrop analogies in gravity-driven mass transport deposits. Our study freshly addresses the complexity of intrasalt structures and multi-phase deformation history recorded in the Levant Basin during and after the Messinian Salinity Crisis. Importantly, we have demonstrated the importance of outcrop analogy at unravelling the history of heterogeneous seismic-scale structures.

THE EARLY POST-RIFT INCISED-VALLEY FILLS ALONG THE EASTERN MARGIN OF THE CONGO BASIN (SOUTH ATLANTIC), APTIAN CHELA FORMATION

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The Congo basin displays marginal incised-valley fills, which are for longtime missed of in many previous geological studies. We have mapped three of these incised-valley systems, informally named Doumanga, Nkougniand and Mboubissi incised-valley systems, which extend from the Mayombebelt in the northeast to the Lower Congo basin in the southwest. In the study area, the incised-valleys cut into the Precambrian metamorphic and magmatic rocks of the Mayombe Basement. Detailed field mapping reveals that the location and morphology pattern of these incised-valley systems were strongly controlled by both tectonic structures and lithology heterogeneities of the underlying basement. They are thought to be cut by rivers which incised into the Precambrian basement and acted as bypass systems prior to their infilling. These incised-valleys systems were filled with Aptian non-marine siliciclastic sediments of the Chéla Formation that is well characterized thanks to rich ostracod and pollen associations. Deposition occurred during the so-called sag phase subsequently to the Aptian regional transgression recorded in the central segment of the South Atlantic. The main sedimentary facies documented in the Chéla Formation are clast and matrix supported conglomerates, structureless and graded sandstones, cross-stratified sand and sandstones, horizontallaminated sand and silt, interbedded sand and silty shale, and organic rich silty shale and shale, which have been grouped into six facies associations interpreted as deposits of flood dominated fan-delta and subaqueous fan interfingering with organic rich lacustrine shales. These deposits are organized into a transgressive sequence bounded at its base by a major angular unconformity and characterized by recurring stacking of finingupward sedimentary packages. It can be suggested that these incised-paleovalleys were filled in the form of backstepping fluvio-lacustrine depositional environment subsequently to the rapid lake level rise during the Aptian period.

HIGH-RESOLUTION CHARACTERISATION OF A MUD-RICH SLOPE SUCCESSION: THE CARBONIFEROUS BOWLAND BASIN, NEW ENGLAND (UK)

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The development of unconventional hydrocarbon systems, where organic-rich mudstones act as both source and reservoir, has led to a substantial interest in fine-grained sedimentary systems. However, to date the focus of research has been on shelfal or basinal successions resulting in a relative lack of studies into mudstone depositional processes acting on mud-rich basin slope successions which has led to a significant gap in the understanding of depositional processes in these settings. This study utilises macro-and microscale analysis of mudstone composition and texture, and organic matter variability from a Carboniferous mud-dominated slope succession from the Bowland Basin (NW England, UK), in order to address this knowledge gap. The Carboniferous Bowland Shale Formation which represents one of the largest potential unconventional targets identified in the UK, was deposited in a series of actively subsiding fault-controlled grabens and half-grabens during the Mississippian (~335 Ma to ~313 Ma).

The study identified a total of six lithofacies, all dominated by turbidites and debrites, which combine to form three basin slope facies associations: sediment-starved slope, slope dominated by low density turbidites, and slope dominated by debrites. Throughout the continuous cored interval variation in slope sedimentation was a function of relative sea-level change, with the sediment-starved slope occurring during maximum flooding of the contemporaneous shelf, and the transition towards a slope dominated by turbidites and then debrites occurring during normal or forced shoreline progradation towards the shelf margin. Organic matter variation (concentration and type, measured using TOC and RockEval) can be predicted within the sequence stratigraphic framework described: the sediment-starved slope succession is dominated by Type II kerogen whereas the slope dominated by low density turbidites is dominated by Type III kerogen. The difference in organic matter type is interpreted to represent a greater contribution from (reworked) deposits of marine hemiplegic settling in the former, and a greater contribution from terrestrially-derived organic material in the latter.

This study suggests that mud-dominated lower slope settings are largely active depositional sites, where there is consistent evidence for sediment traction. Additionally, the composition and texture of basin slope mudstones, as well as organic content varies predictably as a function of shelf processes linked to relative sea-level change. Through understanding and predicting these key sedimentological changes within basin slope settings allows for more accurate quantification and subsequent development strategies for unconventional resources.

INFLUENCE OF THE CONDITIONS FOR FORMATION OF VISEAN COAL IN THE VOLGO-URAL REGION (RUSSIA) ON THE COMPOSITION OF ITS MINERAL MATTER

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Fossil coal is a very informative indicator of sedimentation conditions. Indicative is the coal found in the Visean sediments of the Carboniferous in the east of the East European Platform (Kama basin). It was formed at the same geological time as the coal of the Moscow region basin, has great resources, but because of the great depth of occurrence (900-1400 m) has no economic significance. At the same time, coal is characterized by a certain specific composition and is interesting from the standpoint of reconstructing the conditions of ancient sedimentation.

By natural type, the Visean coal is humic. It is characterized by low ash content (15-26%) and high sulfur content (1.49%-10.22%). Mineral matter is represented mainly by kaolinite, in a subordinate amount are found quartz, albite, calcite, pyrite, etc. The chemical composition of the ash is dominated by silicon oxides (48.90%) and aluminum (39.73%). Coal contains geochemical anomalies of rare-earth elements, mainly Ce. Our studies show that the mineral and chemical composition of the inorganic matter of coal is closely related to the conditions of their accumulation and the composition of the surrounding rocks.

The Visean coal deposits spread area is connected with the area of ancient peat formation on the coastal plains. Coal deposits are distributed fragmentarily and occur only within the limits of depressions on the surface of the Turnaic carbonate sequence. The depressions on the ancient relief are filled with terrigenous sediments of the Visean stage, composed of sandstones, siltstones, mudstones. Among them there are coal seams of various thicknesses, sometimes up to 30-40 m. Most of these depressions are erosive and karstic in origin. Sedimentation occurred under conditions of various facies-streams (alluvium), floodplains of alluvial plains, lakes and marshes. Coal consists mainly of residues of higher terrestrial plants. The Coal formation of Early Carboniferous was formed in the coastal zone under conditions of generally humid lithogenesis. However, for a number of signs (the anatomical structure of the coal-producing plants, the kaolinite composition of the mineral substance, etc.), the climate was characterized by periodic aridity. Sulfur in coal is mainly represented by an organic form, which is due to a deficiency of reactive bivalent iron. The coalbearing carbonate rocks contain small amount of iron. The reason for the increased content of silica, aluminum and low iron content in coal is also carbonate rocks in the surrounding coal sediments. Geochemical anomalies of cerium in the lateral parts of coal seams were formed as a result of its entry into the stage of diagenesis in the composition of groundwater from surrounding carbonate and quartz-feldspar rocks. Thus, the chemical composition of the Visean coal in the Kama basin is related to the geological situation in the area under consideration in the Early Carboniferous.

CARBONATE FACIES DISTRIBUTION OF THE UPPER JURASSIC-LOWER CRETACEOUS MONTE SACRO LIMESTONE IN MONTE DI MEZZO, GARGANO PROMONTORY, SOUTHERN ITALY

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The Upper Jurassic was a period of significant reef development as well as carbonate mound formation. An extensive mix coral-stromatoporoid reefs were dominated in isolated Intra-Tethys platform margins during Upper Jurassic and Lower Cretaceous. The platform margin reef facies of Apulia Carbonate Platform (ACP) and transition to basinal deposits are well exposed in Gargano Promontory, southern Italy. Selected outcrops from Upper Jurassic-Lower Cretaceous Monte Sacro Limestone have been studied in Monte di Mezzo, Gargano Promontory, in order to investigate the distribution of skeletal components and facies architecture. Based on field description and thin section analysis, two main units have been distinguished: 1) Mix coral-stromatoporoid unit and 2) stromatoporoid dominated unit. In the mix coral-stromatoporoid unit, isolated coral colonies (some in life position) and stromatoporoids such as *Ellipsactinia* sp. and *Sphaeractinia* sp., are distributed within a mud-dominated matrix. The dominant morphology of corals is branching (Phaceloid-like) followed by solitary shape, with the size of coral colonies from 10 cm to 80 cm in diameter and up to 50 cm in height. The stromatoporoids are less frequent and mostly broken close to the coral colonies, but well preserved in the other parts. The sediments between components are peloidal wackstone/packstone. The other biotas associated with matrix are fragments of corals, stromatoporoids, sponges, echinoderms, small foraminifers and bivalves. In stromatoporoid dominated unit, the dominant components are well-preserved stromatoporoids (*Ellipsactinia* sp. and *Sphaeractinia* sp.) followed by sponges and chaetetid-like organisms. Corals are rarely present as a single form. The size of *Ellipsactinia* sp. is different from 2 cm up to 12 cm in length. The matrix is dense peloidal packstone with fragments of corals, stromatoporoids, echinoderms, small foraminifers and bivalves. The main structure in both units are stromatactis cavities filled by marine cements. The less number of stromatoporids close to coral colonies in unit 1 and the absence of coral colonies in unit 2 indicate that these two organisms had a different ecological requirement. Moreover, the development of branching coral colonies in growth position, with mud dominated matrix, and presence of broken fragments of stromatoporoids show that the mix coral-stromatoporoid unit was formed under low hydrodynamic energy conditions with episodic high-energy events, while well-preserved stromatoporoid dominated unit was formed in more quiet environments, in distal part of external platform margin.

DELTAIC SEDIMENTS IN MAGONG CRATER, MARS

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Xanthe Terra is part of the ancient highlands of Mars and hosts a variety of fan-shaped deposits which are most likely the result of episodic fluvial activity. One of the deposits is located in Magong crater, a highly degraded, flat-floored impact crater with a diameter of 40 km, located at 11.9°N and 313.2°E. The sedimentary deposit is situated at the terminus of Sabrina Vallis, a valley system which extends over 250 km through Noachian highlands west of Magong crater. It covers ~20% of the overall crater area. Earlier observations based on orbital spectroscopy revealed weak signatures linked to Fe-/Mg-phyllosilicates that indicate the past presence of liquid water in Magong crater. The deposit exhibits well-exposed sub-horizontal layering at steep erosional cliffs on its eastern and southern margins. Individual layers can be traced laterally for over 1 km. In contrast to the steep eastern margin, the transition from the deposit to the crater floor is rather shallow in the North. The overall slope of the surface is shallow at ~1°. The top surface of the deposit is covered with dust and aeolian bedforms. Possible channels on top of the deposit are hardly visible. A shallow topographic moat at the foot of the eroded cliffs surrounds the deposit in the south and east. The floor of the moat lies up to 10 m deeper than the crater floor and displays an orthogonal pattern of polygonal fractures. Some fractures can be found outside this moat, but there they are not as well-developed. The cracks are ~2 m deep, 10 m wide and extend for up to 1 km. They are filled with aeolian material. The crater floor is flat, with elevations slightly increasing westwards. Various impact craters are filled with aeolian material, whereas others are filled with a dark material. Dark material also forms elevated patches on the crater floor which can be as large as 13 km^2. Smaller patches can also be found on top of the fanshaped deposit and in ejecta blankets. These patches are not limited to Magong crater, but are widely distributed across the surrounding highlands and adjacent impact craters such as Lederberg crater. The thickness of the dark patches varies, and can reach up to 4 m. No such patches can be observed in the polygonised areas. A possible explanation for the dark material is possibly tephra ejected by a volcanic field located in Lederberg crater, although there is no strong independent support for this hypothesis. Another possible magmatic landform is a straight, NE-trending topographic ridge that crosses the crater floor east of the sedimentary deposit and may be an exhumed dike. Other possible dikes were identified near the southern crater rim. According to crater counts, Sabrina Vallis formed at 3.8 Ga, whereas the delta represents the last stage of fluvial activity at around 3.4 Ga. An episode of erosion at ~2.2 Ga exhumed the polygonised areas and eroded the dark patches. We will present observations that suggest that the sediments formed in a prograding delta in a crater lake.

THE ROLE OF BEDROCK STRUCTURE IN SHORE PLATFORM DEVELOPMENT: AN EXAMPLE FROM SOUTH AFRICA

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Shore platforms found along bedrock coasts worldwide are often interpreted as due to the simple impact of waves on uniform bedrock surfaces. Whilst this viewpoint may apply at the macroscale, there are complex feedbacks between bedrock properties (rock type, mineralogy, rock structures), weathering and erosion processes and rates, and microtopography. In turn, these impact on wave runup, backwash processes, and extent of wavesplash. This study investigates the relation ships between bedrock properties, weathering and shore platform erosion from Cintsa West (32°50'40"S, 28°7'8"E), on the Indian Ocean-facing coast of the Eastern Cape, South Africa. This coastline is high microtidal and is fronted by Paleozoic sandstones that dip shallowly northwards. Here, three shore-normal transects (40-80 m apart) were surveyed across a rock shore platform (42-65 m width) using a differential GPS. These data were integrated with rock surface hardness measurements taken using a Proceq Equotip instrument. Results show that geologic structural control on platform morphology varies considerably over small spatial scales, and that there are complex microscale variations in rock surface hardness and inferred weathering rate that are most likely controlled by rock heterogeneity, including the presence of concretions within the host sandstone.

SALTMARSH SEDIMENTS AS A RECORD OF COASTAL EVENTS

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Saltmarsh sediments are problematic as sea-level indicators because sediments can accumulate by tidal, wave, aeolian and overwashing processes at a range of elevations within the tidal frame. In addition, saltmarsh sediments often have low preservation potential due to wave/tide erosion and sediment reworking, and sequences that are preserved can exhibit erosional hiatuses of unknown length that condense the record and give undue prominence to the significance of high magnitude events. Aggradational saltmarsh sequences may be preserved, however, where there is rapid coseismic subsidence or where sediments become trapped within a bedrock basin. The Atlantic-facing coastline of northwest Ireland provides a good example of the latter case, where bedrock headlands and an archipelago of small offshore islands has provided accommodation space for aggradational saltmarsh sequences which regionally are of mid to late Holocene age. At Burtonport (County Donegal, northwest Ireland) individual saltmarsh sediment packages (20-80 cm thick) are bounded by undulating erosional unconformities, and the total saltmarsh sequence (2.8 m thick) develops upwards from in situ Pinus stumps (located within the upper foreshore) overlying beach gravels and weathered granite bedrock. Above this base, organic-rich saltmarsh sediments are interbedded with laterally continuous sandy layers (< 1 cm thick) which generally increase in thickness upwards at the expense of the organic layers. The succession is transitional to an overlying palaeosol (20 cm thick) and 60 cm of recent dune sand. High-resolution analysis of grain size, combustible organic carbon content, magnetic susceptibility and diatom assemblage composition through the entire succession shows distinct variations, which reflect the relative and evolving role of tidal overwashing and/or aeolian deposition during emergence of the saltmarsh succession. These changes are set within a dating framework provided by radiocarbon ages through the profile, and can be compared to regional sea level and climate records.

MULTISCALE CHARACTERISATION OF FAULT-CONTROLLED DOLOMITISATION FRONTS: AN EXAMPLE FROM MIDDLE CAMBRIAN PASSIVE MARGIN CARBONATE PLATFORM, WESTERN CANADA

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Dolomitisation of carbonate rocks is a critical process controlling the petrophysical and fluid flow properties of carbonate rocks, yet the processes governing the shape, size and spatial distribution of dolomite bodies, in particular, controls on the termination of dolomitisation fronts are not well studied. This research aims to provide insight into: (i) the range of dolomitisation front geometries; (i) the processes governing the termination of dolomitisation bodies (ii) the importance of precursor petrophysical and textural properties on the propagation of dolomitisation fronts. Understanding the spatial changes in dolomite characteristics within partially dolomitised platforms can provide useful information about the migration pathway and nature of dolomitising fluids. Ultimately, it can potentially act as a robust predictive hydrocarbon exploration tool and lead to a better understanding of fluid flow pathways in carbonate rocks.

The Middle Cambrian carbonate platform in Western Canada Sedimentary Basin (WCSB) near Whirlpool Point, Alberta provides a superb opportunity to characterise a spatially restricted body of dolomite with various termination geometries with the host limestone. The most prominent structural element in this study area is the Precambrian-inherited NE/SW trending normal fault system with subordinate NW trending thrust fault. This fault system is believed to have provided a major pathway for the flux dolomitising fluids. The extent and termination of dolomite bodies are highly dependent on the presence of depositional and diagenetic barriers, availability and/or capability of Mg-rich fluids, and local fluid flow history. Other controls such as fault-geometry and distance to fault might also play important roles in governing the termination geometry of dolostone geobodies and need to be more investigated.

Dolomite bodies are both stratabound (sheet-like bodies) that extend laterally for at least tens of meters, and non-stratabound, cross-cutting strata. Combined petrographic and geochemical studies reveal that there are at least four distinct dolomite types in this formation that possibly correspond to multiple dolomitisation events, including: (i) replacive dolomite, (av. $\delta^{18}O$(PDB) = -16.9‰ and $\delta^{13}C$(PDB)= -0.77‰); (ii) dolomite cement (av. $\delta^{18}O$: -16.77‰ and $\delta^{13}C$: -0.80‰); (iii) saddle dolomite (av. $\delta^{18}O$= -15.76‰ and $\delta^{13}C$= -0.60‰); and (iv) "slurry" dolomite (av. $\delta^{18}O$= -15.25‰ and $\delta^{13}C$= -0.29‰). The $\delta^{13}C$ values are rock-buffered (host limestone; $\delta^{18}O$ =12.28‰ and $\delta^{13}C$=0.73‰) and fall within the range of dolomite precipitated from Middle Cambrian seawater (-1 to 1‰ PDB) while $\delta^{18}O$, even though tightly clustered (vary in range of 2‰), are depleted relative to postulated values of dolomite precipitated in equilibrium with Middle Cambrian seawater.

Both sharp and gradual transitions between dolomite and limestone are present in this study area, with the textural variability in dolomite occurring where transitions are gradual. The margins of the dolomitisation front comprise non-stoichiometric, calcian dolomites (avg. 58 mole% $CaCO_3$) while the core of dolomite bodies are near stoichiometric (avg. 51 mole% $CaCO_3$). Additionally, the core of the body shows more well-ordered dolomite crystals than on the margin. An increase in porosity and permeability has also been recorded on the margin of the dolomite bodies, perhaps associated with partial dolomitisation of the limestone matrix.

LOWER PENNSYLVANIAN RESERVOIR FACIES FROM THE FORELAND BASIN CARBONATE RAMP OF THE VOLGA-URAL REGION, EAST OF RUSSIAN PLATFORM, RUSSIAN FEDERATION

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Bashkirian (Lower Pennsylvanian) carbonate successions are relevant hydrocarbon reservoirs in the subsurface of the Volga-Ural region in the South-East of the Tatarstan Republic (Russian Federation). The studied Bashkirian succession represents an eastward dipping, low-angle carbonate ramp belonging to the Russian Platform developed on the distal margin of the West Uralian foreland basin. The Bashkirian carbonate strata were investigated in 20 wells from several oilfields in the region for a total thickness of more than 700 m. The Bashkirian carbonate succession is nearly 35-45 m thick comprised between Serpukhovian and Moscovian carbonate rocks. Total thickness of Serpuhovian carbonates varies from 70 to 130 meters and rocks represented by detrital and poloidal packstone and wackestone. Moskovian strata is represented by detrial and peloidal packstone and grainstone interbedded with laystone, rarely with sandstones. Total thickness varies from 150 to 270 meters. The Bashkirian carbonate strata consist of: a) skeletal peloidal packstone and grainstone cemented by blocky sparite including common benthic foraminifers (endothyrids, staffellids, globivalvulinids, *Ozawainella*, *Climacammina* and *Bradyina*), echinoderms, brachiopods, gastropods, bivalves and *Donezella* algae fragments; b) coated grain grainstone with thin isopachous marine cement rims including micrite coated grains, superficial ooids, aggregate grains, coated grain intraclasts, benthic foraminifers and crinoids; the open interparticle porosity is often filled by hydrocarbons; c) mudstone with rare peloids, calcispheres and ostracodes; d) rugose coral coundstone. These facies are indicative of inner to middle ramp settings with high-energy, above-wave base coated grain grainstone, open marine subtidal peloidal skeletal grainstone to packstone and coral biostromes, and shallow calcisphere-rich mudstone accumulated in restricted lagoon. These Bashkirian inner to middle ramp facies display vertical thickness variations in each core and among the various sections. The average thickness of the skeletal peloidal grainstone and packstone is 2-3 m (ranging from 7 to 0.5 m). The other facies show thicknesses of 1.5-2 m. Vertical facies stacking is organised in metre-scale shallowing upward cycles from subtidal open marine grainstone facies to restricted mudstone. The high lateral facies variability at the metre scale makes it difficult to correlate from core to core even at 2-3 km spacing. Oil saturation occurs in correspondence of high-energy poorly cemented coated grain grainstone, and in some cases also in skeletal packstone, where primary interparticle porosity appears to have been enlarged by secondary processes of leaching during burial corrosion. Leaching during burial diagenesis must have enhanced the primary porosity of subtidal high-energy grainstone and generated secondary porosity in skeletal packstone. This study demonstrates the high lateral variability of facies types and reservoir properties in shallow-water ramp carbonates during the Bashkirian time.

DIAGENESIS OF THE PALAEO-OIL-WATER TRANSITION ZONE IN A LOWER PENNSYLVANIAN CARBONATE RESERVOIR

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Oil-water transition zones in carbonate reservoirs represent important but rarely studied diagenetic environments that are now increasingly reevaluated because of their potentially large effects on reservoir economics. Data from cathodoluminescence, isotope geochemistry, and microthermometry of fluid inclusions are combined to decipher the diagenetic history of a 5-m-long core interval comprising the oil-water transition zone in a Lower Pennsylvanian carbonate reservoir. The aim is to understand the diagenetic processes during and after oil emplacement and changing fluid parameters in time. Carbonate cements formed from the earliest marine to the late burial stage. Five calcite (Ca-1 through 5) and one dolomite phase are recognized with phase Ca-4b recording the onset of hydrocarbon migration. Carbon and oxygen cross-plots clearly delineate different paragenetic phases with Ca-4 representing the most depleted $\delta^{13}C$ ratios with mean values of about -21‰. During the main phase of oil emplacement, arguably triggered by far-field Alpine tectonics, carbonate cementation was slowed down and eventually ceased in the presence of hydrocarbons and corrosive fluids with temperatures of 110-140 °C and a micro-hiatal surface formed in the paragenetic sequence. These observations support the "oil-inhibits-diagenesis" model. The presence an earlier corrosion surface between phase Ca-3 and Ca-4 is best assigned to initial pulses of ascending corrosive fluids in advance of hydrocarbons. We propose that diagenetic processes in water-oil transition zones go on also after the oil charge. Between phases Ca-4b and Ca-5 a second micro-hiatal surface was recognized resulting from corrosion of previous cement phases and precipitation of final cement phase. The final Ca-5 calcite phase results from the post-oil charge stabilization of the diagenetic environment at the oil-water surface. The short-lived nature of the oil migration event found here is rather uncommon when compared to other carbonate reservoirs. The study is relevant as it clearly documents the strengths of a combined petrographic and geochemical study in order to document the timing of oil migration in carbonate reservoirs and its related cementation dynamics.

BURIAL DOLOMITIZATION OF LOWER MISSISSIPPIAN RESERVOIR ROCKS FROM THE VOLGA-URAL BASIN, RUSSIA

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Identifying the type of Carboniferous dolomites is a general problem for reservoir geology in the Volga-Ural region. There, dolostones have good reservoir properties and developed in combination with with oil-saturated limestones. The main aims of this study are to determine (i) the site and timing of burial dolomitization and (ii) to link dolomite precipitation and hydrocarbon migration in the Volga-Ural basin. For this purpose, Tournaisian dolomites from several oilfields characterizing different areas of this region were studied. The dolomites show significant similarities and differences across all fields studied. Differences are visible specifically with reference to isotope and geochemical data, fluid inclusion data and temperatures of homogenization. Cathodoluminescence studies document that dolomites display complex zoning, with five to six generations recognized depending on the thin section studied. Temperatures of homogenization of fluid inclusions in dolomites vary from 170 to 200°C. Next to Tournaisian dolomites, Visean dolomites were detected in a limited number of fields. Dolostones are mainly located on the flanks of oil reservoirs and form isolated bodies embedded in dense limestones. Visean dolomitesare similar to Tornaisisan dolomites including their homogenization temperatures and the composition of fluid inclusions. Freezing temperatures vary between -70 and -100°C. Fordolomites, the final melting temperature of ice varies from -22.9 to -26.2°C and final dissolution temperatures for hydrohalite between- 28.7 and 35.6°C, recording a salinity of fluids varying between 22-24 wt.% ($NaCl + CaCl_2$). The isotope geochemistry of dolomites plots within a similar range as that of the bulk carbonate rock with $\delta^{13}C$ values ranging from 0.3 to 2.4‰ and $\delta^{18}O$ values from – 2.0 to- 6‰. This overall homogenous pattern indicates a single major fluid migration through different stratigraphic intervals and clearly points to hydrothermal dolomitization processes. The presence of hydrocarbon inclusions in the dolomites indicates an abnormally high temperature background of the basin. High homogenization temperatures of fluid inclusions in calcite rich in hydrocarbon inclusions (107-140°C) from overlying Lower Pennsylvanian deposits confirm this. The authors assume that dolomitization was a process resulting from the migration of ascending heated fluids, including hydrocarbons, that transported and formed oil deposits at various stratigraphic levels in the basin.

GEOCHEMICAL AND C-O ISOTOPIC SIGNATURE OF THIOUNTA ANTIQUE MARBLES (DENIZLISW TURKEY)

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Thiounta marbles are one of the most treasured white marbles in ancient Lykos valley (Denizli). They were commonly used for sarcophagi, especially during the Roman Imperial period. Regarding the use of Thiounta marbles, at least four inscriptions from the Hierapolis necropolis have been documented. Macroscopic investigations reveal that the Thiounta marbles can be grouped into three types, based on color and foliation status. These groups are described as white, bluish gray-veined and bluish gray marbles. Microscopically, the white and bluish gray veined marbles have homeoblastic mosaic texture while bluish gray marble has heteroblastic mosaic texture. Thiounta marbles mainly composed of calcite ± dolomite (white, bluish gray veined) and calcite ± dolomite ± quartz ± muscovite ± opaque minerals (bluish gray). XRD investigations also confirm this mineralogical composition. In terms of major oxide and trace elements, marbles show similar and limited compositional spreads. The Mg/Ca-SiO_2 diagram is one of the most useful discrimination diagrams for protolith of marbles. On the Mg/Ca-SiO_2 diagram, the marbles of Thiounta fall in the limestone field. The Mg/Ca ratios ranging between 0.007-0.025 for white marbles, 0.006-0.125 for bluish gray veined marbles and 0.008-0.049 for bluish gray marbles. The low Mg/Ca ratio (< 0.02) of marble groups demonstrate that calcite is the individual carbonate mineral present. In Average Phanerozoic Limestone normalized multi-element variation diagrams, the elemental patterns of Thiounta marbles are highly similar to each other. In terms of isotopic composition, while $\delta^{13}C$ isotope values range between 0.55-2.24 in white marbles, (-1.09)-2.26 in bluish gray-veined marbles and (-0.28)-(-0.04) in bluish gray marbles, $\delta^{18}O$ isotope values change between (-3.82)-(-3.24); (-3.09)-(-2.55) and (-3.27)-(-2.93) respectively. On the $\delta^{13}C$-$\delta^{18}O$ isotope diagram, Thiounta marbles are similar in composition, displaying clustering in the vertical direction. Furthermore, bluish gray veined and bluish gray marbles have negative value of their isotopic carbon and oxygen ratios. Minero-petrographic, geochemical and C-O stable isotope results reveal that marble groups of Thiounta have orginated from a metamorphism of limestone protolith.

SUB-SEIMIC SCALE SAND INJECTITES IDENTIFICATION USING 3D SEISMIC FREQUENCY ATTRIBUTES

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For decades, numerous networks of sand injectites in sedimentary basins worldwide were interpreted from seismic data. Forceful sand injection sealed by low-permeability lithologies is the most common process involved in the formation of active injection. It is due to overpressuring of a sand body during burial until the pore fluid pressure exceeds the fracture strength of the host rock. This process forms millimeter to kilometer scale hydraulic fractures, perpendicular to the minimum compressive stress, filled by a sand-fluid mixture when the velocity of fluidization is reached.

Our study area is located offshore Norway, in the Vøring basin which developed during several rifting phases in the mid–late Jurassic, the Late Cretaceous and before continental break-up in the Early Eocene. During the Oligocene and Miocene, this part of the margin underwent a period of compression resulting in several dome structures. The most prominent one extends into the study area and is called the Helland-Hansen Arch, a north–south-striking 280 km long anticline.

The data used in this study consists of a mega 3D seismic survey merged from two different acquisitions covering an area of about 5000 km^2 with In-line and crossline spacing of 25 m, our zone of interest belongs to the Naust Formation; an interbedded claystone, siltstone and sand lithology at a depth of 1450-1550 ms TWT where we estimated a 12 m vertical resolution.

It is particularly difficult to identify such injectite networks on exploration seismic as the dimension and distribution are very close to the seismic resolution. It has already led to mis-interpretations, such as channels instead of sills for instance. The challenge will be to define a geophysical methodology in order to detect such sub-seismic sand injectite networks.

We generated several seismic attributes on our amplitude preserved cube. In particular, we used the iso-frequency component attribute at 70Hz, this attribute gives the contribution of this individual frequency to the make-up of the input seismic signal. It is useful for isolating frequency-dependent changes in the signal, such as stratigraphic thinning and fluid effects.

On a seismic section, we identified a one km wide high amplitude reflector ending with a wing-shaped sloped at 30° extending for 300 meters but with a small thickness. It was then possible to clearly visualize the limits of the structure on a time slice by applying the Generalized Spectral Decomposition at three different frequencies (15-20-45) Hz, and displaying simultaneously the three seismic attributes by assigning each of them a specific opacity and a specific color (red, green or blue) through the RGB color blending technique.

The proposed methodology based on iso-frequency and Generalized Spectral Decomposition allowed the identification of sub-seismic large wings on top of the anticline structure. The model is based on the assumption that fluids coming from greater depths are progressively concentrated on top of the structure in sandy intervals. Once the requested overpressure is reached, sand is fluidized creating the injected network. A detailed analysis of 3D seismic data shows that the network is then reused by later fluids forming chimneys.

EOLIAN FISSURE FILLING SEDIMENTS OF KARSTIFIED LIMESTONES IN THE CARPATHIAN BASIN

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The filling sediments of fissures and caves of various origin were studied in the northern and southern part of the Carpathian Basin. The sediments represent various red clays (red paleosols), redeposited loess and in some cases sandy siltstones as well. The granulometry of these sediments was studied by laser diffraction method (Malvern Mastersizer 3000, Hydro LV). Special attention was paid to the geological relations of the localities. The study sites were: Ivanovce and Včeláre (Slovakia), Beremend and Csarnóta (Hungary). According to the morphological characteristics, the rodent association from these localities can be placed in the Pliocene and Early Pleistocene.

Mesozoic paleokarst limestones served as a dust trap for the Pliocene/Pleistocene red clay (paleosol) deposits in the Carpathian Basin. This study evaluates a silt/clay-rich geological deposit, paleocave/karst fissures sediments derived from mixtures of dust (eolian silt) and karst breccias. Evidence that the fluvial cave/fissure sediments in the Triassic–Cretaceous limestones are derived from this eolian red clay includes compositional and textural matches, especially grain size distribution trends vertically downward from the former landscape surface. These grain size trends indicate infiltration of the eolian red clay into the underlying karst system. The deposits also contain abundant vertebrate fossils. Faunas accumulated in fissure fillings of karstified limestone and thus provide a minimum age for the subaerial exposure (exhumation) of the bedrock at the given site.

Various environmental factors could be recognized by the statistical evaluation of the grain size distribution curves of fissure fillings and cave sediments, like the effects of eolian transport, type of the parent rock, the weathering process and ways of underground sediment transport. Cave sediments have distribution curves with a single/double maximum in the clay size class. Distribution curves with a single maximum in the silt size class are typical for the debris of the overlying siltstone, for the redeposited loess and for the red paleosol underlying the loess. Red clay fissure fillings display bimodal distribution curves with maxima both in the clay and silt classes.

Late Cenozoic cave/fissure sediments are increasingly utilized as archives of geologic change. The role of dust (eolian silt), including its inherited compositional and textural properties from a distant source area, land-atmosphere transfer processes, and resedimentation processes on the land surface overlying the cave-karst system, remain promising areas for research.

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HETEROGENEITIES OF THE VACA MUERTA FORMATION IN THE NEUQUÉN BASIN: LITHOLOGY AND GEOMETRY FROM THE OUTCROP TO THE SUBSURFACE

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The Vaca Muerta Formation, an upper Jurassic-lower Cretaceous unit (Figure 1), represents the most important source rock of the Neuquén Basin (Argentina). It constitutes also the major unconventional play in Argentina and consists of organic-rich, dark brown to black shales and mudstones deposited during a major transgression.

The geometry, spatial relationships and lithology of this unconventional reservoir were studied using seismic 3D and outcrop data in several points of the basin.

Two major sectors were defined. The first one corresponds to the central and southern part of the basin (from Picún Leufú Anticline to Chos Malal) where an evolution from a siliciclastic shelf to a mixed ramp setting is observed during the Tithonian-Valanginian interval. Sediments were redistributed along the shoreface by longshore currents and further transported by storm and gravitary currents basinward. To the North of the basin (Malargúe area), a perennial carbonate ramp with is observed with volcanoclastic supply during the same time-interval. This sector is dominated by fine-grained facies corresponding to the outer ramp/basin and occurrence of storm currents in the middle ramp. According to Kietzmann et al. (2014), this sector corresponds to two prograding systems.

Sequence stratigraphy analysis of all areas shows an homogeneous signal with five transgressive-regressive sequences. In detail, several 10 meters-scale sequences are observed with a high lateral variability; they define an overall transgressive-regressive pattern.

The stratigraphic correlation of the different sectors suggests two evolutions of the basin during the Tithonian-Valanginian. The southern and the central part of the basin show a regional straight prograding system from the south. In detail, this system is influenced d by the Huincul Arch; a local tectonic barrier, to the east (Figure 1). The north part of the basin shows a carbonate-dominated ramp with prograding geometry from the east.

LA-ICP-MS STUDY OF THE REEY DISTRIBUTION AND REDOX OSCILLATIONS DURING THE END-DEVONIAN HANGENBERG CRISIS IN THE MORAVIAN KARST PALAEOZOIC (CZECH REPUBLIC)

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The redox oscillations and REEY distribution were analysed using laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) in the latest Famennian thin laminated limestone (laminite; *costatus-kockeli* Conodont Interregnum) corresponding to the Hangenberg Black Shale Event and in the underlying pre-event calciturbidite (*praesulcata* Conodont Zone) from the Moravian Karst, Czech Republic, Central Europe. Carbonate petrography evaluating depositional environments and a scanning electron microscope study covering the mineral content were performed. Our study documents the origin of authigenic microbial limestones during the latest Devonian Hangenberg extinction event, when unusual oceanic conditions appear to have led to the enhanced precipitation of calcite within microbial carbonates.

The laminite consists of microbially bound dark micritic lenses to and laminae with clotted structure and microsparitic matrix of probable hydrogenous origin. The detrital contamination of the pure laminated limestone is very low, as demonstrated by low contents of Al, Zr, Ti and Th. The early diagenetic overprint of limestones but the absence of a late diagenetic one is evidenced by several proxies. High authigenic U–Mo enrichment and their covariation patterns indicate suboxic to anoxic variations in the laminite. Oxic conditions in the underlying calciturbidite were brought by turbidity currents. High P enrichments are in accord with the formation of authigenic apatites. REE content in both the laminite and calciturbidite, nearly ten times higher than in most modern carbonates, may reflect several sources – microbialites, apatites, hydrothermal influence. The typical feature of the REEN record is a less (laminite) and a more prominent (calciturbidite) MREEN bulge. However, even though the ablation points with high P have a higher concentration of REEY, their structure is similar to the ablation points with low P content. Negative Ce anomalies are in contradiction with Uenr-Moenr crossplots revealing suboxic to anoxic redox oscillations. However, redox oscillations did not exert any influence on Ce/Ce*. The negative Ce and positive Eu anomalies, low Y/Ho ratio, and very low Al/(Al+Fe+Mn) ratios suggest some influence of diluted high-temperature hydrothermal fluids related to the latest Devonian magmatism of the active rift basin in the eastern part of the Rhenohercynian zone.

The proliferation of anachronistic facies following the D-C extinction event recognized in Moravia and traced worldwide seems to share some features in common with anachronistic carbonate sequences documented in the aftermath of the end-Permian mass extinction.

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DIAGENESIS OF DOLOMITE RESERVOIR IN TAZHONG AREA, TARIM BASIN, CHINA

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The Yinshan Formation carbonate reservoirs in Ordovician are one of the main exploration targets in Tazhong area of the Tarim Basin. In gereral, pore of sedimentary rock would disappear after it is buried over 6000 meters. However, carbonate reservoirs with good porosity and permeability are found to occur in the Yingshan Formation with burial depths more than 6000 meters, especially, some dolomite reservoir shows porosities up to 17%. The pores in those reservoirs are likely to be secondary and were formed during the diagenesis stage. Thus the researches on the origin of those secondary pores have important implications to the exploration and production in Tazhong area.

Firstly, based on the data of the core description of 32 coring wells, microscopic observation and cathodeluminescence of core slice and the characteritics of the core slices in the electron microscope, this paper classifies the diagenesis types, describes the characters of the carbonate cements and measures homogenization temperatures of fluid inclusions in the carbonate cements, and finally built the diagenesis sequence.

Secondary, based on oil field water chemical composition, strontium isotope and the results of the water injection point on the fracture research in Tazhong area, this paper analyzed the source and flow direction of the fluid. Finally, the origin of the high porosity dolomite reservoirs in Yingshan formation in Tazhong area is discussed.

The Yingshan Formation is considered to have suffered from dissolution, rupture and cementation during syndiagenetic stage. Subsequently, the formation suffered from karst dissolution when it was uplifted during Caledonian stage. The eastern part of Yingshan Formation in Tazhong area was uplifted and suffered from the rupture during Hercynian stage. Fluorite, celestite and calcite was precipitated from hydrothermal fluid flowing upwards along its cracks during the tectonic activities. Three generations of calcite cements are obverved from Yingshan Formation. They were precipitated during Caledonian stage, Hercynian stage and Himalayan stage respectively, based on the homogenization temperatures of fluid inclusions in calcite cements and burial history. Pressure solution, metasomatism and hydrothermal dissolution may have occurred after Hercynian stage.

Based on chemical composition and strontium isotopes of oil field water and the potential water injection point as proposed by previous researchers, the source of the fluid and traced the direction of fluid are analyzed. The hydrothermal fluid is considered to flow along the faults-cross-point between the strike-slip fault and the main fault. The fluid flowed southwestward, southward and southeastward, and resulted in dissolution and dolomitization of the limestone reservoir. Thus, the porous dolostone reservoirs of Yingshan Formation area were concluded to have been formed from high porosity limestone reservoirs, which experienced karst dissolution when the formation was uplifted to the surface, and subsequently suffered from hydrothermal dolomitization and hydrothermal dissolution.

THE LACUSTRINE SEDIMENTS OF HIGH-ALPINE TOTENSEE (SWISS ALPS): A RECORD OF POSTGLACIAL PALEOENVIRONMENT, HYDROTHERMAL ACTIVITIES AND NEOTECTONICS

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The Grimsel Pass area (Bernese/Valais Alps; Switzerland) hosts an active fault-controlled hydrothermal system in the crystalline basement of the Aar Massif. This system documents at least 3 Ma of hydrothermal activity along a shear zone, which partly cuts through the Totensee, a small lake located on the Grimsel Pass at an attitude of 2160 m a. s. l. This lake formed in gneisses and granites of Variscan and older age as a glacial overdeepening during the last ice ages. The lake has a surface area of 0.18 km^2 and a maximum water depth of 34 m.

In this study, the Quaternary glacial and lake sediments will be targeted to provide a high-resolution archive of environmental and climate change as well as of human impact. Two high-resolution seismic surveys were conducted in summer 2016 producing a detailed seismic stratigraphy of the lacustrine sediment fill with a maximum sediment thickness of 12 m. Some discontinuities in the subsurface, matching irregularities in lake floor bathymetry, indicate the continuation of the shear zone through the lake. In the northern part of the lake, sediments appear rather undisturbed, whereas in the southern part, i.e. the deepest basin, mound-like features occur along the shear zone indicating either i) a mass movement that accumulated distally in the basin or ii) effects of fluid discharge and sediment remobilization. In some areas, an unlayered lowermost seismic sequence overlying basement was interpreted to represent glacial deposits (basal till).

Two short sediment cores show banded sediments with layers of different color and thickness. Light brown layers are normally graded and contain a high content in quartz and feldspar and some mica. They are interpreted as flood layers caused by extreme precipitation events. They are intercalated within finer and darker sediment interpreted as regular background sediment. The flood layers contain 1-3% of organic matter and no carbonate. The background sediment contains a higher amount of organic matter (4-8%) and low carbonate content < 3%.

In summer 2017, two long sediment cores of ~10 m length will be taken, one in the undisturbed background section in the north, and one in the major mound-like feature in the deep basin. The northern core will provide the backbone paleoenvironmental record, while the southern core will allow to disentangle the potential causes for the basinal sediment mound. These sediment cores thus will help to understand the postglacial lake evolution including various natural hazards occurring on the Grimsel Pass during the last >10’000 years.

THE GORDO MEGA BED: HYBRID AND MULTI-SOURCE MASS-TRANSPORT DEPOSITS IN THE EASTERN BETICS (SOUTH SPAIN)

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Large-scale Mass-Transport Deposits (MTD) with long-distance runout are commonly described on modern continental margins, both passive and active, in a wide range of climate and tectonics setting. Sealevel changes, earthquakes, high-sediment supply and fluid charging among others are usually claimed to be responsible for the triggering of such MTD, but identification of the triggering factors usually still suffers from a lack of observation/measurements and robust criteria. Similar large-scale MTD are little observed on the field but their study should fill the gap with modern-margin observations. The intra-mountain basins of the internal zones of eastern Betics are an excellent example to illustrate the impact of both tectonics and sedimentological processes on the initiation of MTD in an active seismic context.

The Tabernas basin, located between the Sierra de Los Filabres and Sierra Alhamilla, is a Late Neogene sedimentary basin formed during the post-orogenic extension of the Betics cordillera. The flooding of the basin is marked by transgressive sedimentation from the red basal continental conglomerates to the Tortonian fine turbidite sequence. Numerous seismic-scale MTD are well-preserved in the Upper Tortonian turbidite interval. Five MTD were studied in detail, based on sedimentological observations and statistical analysis on the orientation of deformation structures (folds, faults, injections). The Gordo megabed is the largest MTD that crosses the basin.

The characterisation of the upstream zone of the Gordo Megabed revealed two distinct modes of transport. The principal initiation zone is affected by a succession of normal faults trending N130 to N150 and dipping to the west. They delimit poorly-deformed plurimetric rafted blocks of turbidites bounded by compressional structures in downstream and extensional zone in upstream. Normal, reverse faults and folds in the rafts have similar direction. All of these structures indicate a south-westward slide direction. Rafted blocks are separated by massive strongly cohesive debris-flow facies with metric metamorphic-rock clasts and small-scale bodies of folded turbidite beds. The orientation of the folds measured within the debris flow exhibits a dominant N060 trending, perpendicular to the faults trend. This N060 trending and the nature of clasts (black schist and quartzite) indicate a South-eastward flow direction. We suggest that the debris flows were temporally stocked in the basin possibly near major faults and are incorporated in the slide from the Nevado-Filabride complex by following the escarpment of the major N150 normal faults. A multi-source model is so proposed here: the debris flows and the rafts would result from two different events, the second one corresponding to the sliding raft event incorporating and thrusting the pre-existing debris flow. We suggest also that slide initiation is governed by the tectonics activity along deep-rooted NW-SE faults. Those faults controlled the overall dip of the basin and local morphology and the segmentation into individual rafts.

HOLOCENE CLIMATE RECONSTRUCTION BASED ON MULTI-ARCHIVE ISOTOPE RECORDS FROM CENTRAL SWEDEN

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Holocene climate proxies can be challenging to interpret as we are often faced with relatively subtle changes and low signal-to-noise ratios. Climate reconstructions for the Holocene therefore require high quality proxy data, including replication of records and robust chronologies. In the context of multi-archive comparisons, oxygen isotope ratios ($\delta^{18}O$) are highly useful and sensitive climate proxies as the water originating from precipitation is involved in the formation of many different natural climate archives.

The goal of this project is to reconstruct precipitation $\delta^{18}O$ variability in northern Europe throughout the Holocene in order to improve our understanding of the underlying regional atmospheric dynamics. We have sampled living and subfossil trees, speleothems and lake sediments in the region of J´'amtland, central Sweden. The speleothem and lake sediment records cover the entire Holocene, the trees almost continuously the period from c. 6800 cal BP to present.

Although different physical, chemical and biological processes steer the formation and preservation of the archives and modify the original atmospheric $\delta^{18}O$ signal, we observe a good agreement in the longterm trends of the lake carbonate and speleothem isotope records. Synchronous abrupt changes confirm the common climatic influence on both archives, as well as the accuracy of the independent chronologies. However, we also identify a period of diverging trends in $\delta^{18}O$ between 3,900 and 3,300 cal BP. This can be interpreted as a change in seasonality, as the lake carbonates are formed in the summer and the speleothems likely represent an annual signal. Tree-ring isotope measurements are in progress and the addition of this summer proxy will allow for testing of our hypothesis.

Our multi-archive approach will allow us to distinguish non-climatic influences on each archive from their common regional climatic influences. The replication of records from different independently dated archives will thus improve the reliability and representativeness of precipitation $\delta^{18}O$ reconstructions.

DIAGENESIS CONTROLS ON RESERVOIR QUALITY IN TIGHT OIL SANDSTONES

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Tight oil and gas reservoirs are an important source of the increase of reserves and production in the Ordos Basin. The Yanchang Formation, which can be subdivided into ten members, named Member Chang 1 through Chang 10 from top to bottom, include significant tight oil resources. The Chang 7 tight oil reservoirs are important oil exploration targets in the Ordos basin. Large volume of oil has been produced from the deep water gravity flow sandstones (sandy debrite, turbidites) within Chang 7 member. The reservoirs are generally characterized by low porosity, low permeability and strong microscopic heterogeneity. Mineralogical, petrographic, and geochemical analyses have been used to investigate the type and degree of diagenesis and diagenetic history of Chang 7 tight oil reservoirs. The influences of composition, texture and diagenesis on reservoir quality were also discussed in this article. Diagenesis of the Chang 7 tight oil reservoirs was mainly composed of mechanical compaction, grain dissolution and cementation by quartz, carbonates and various clay minerals. Reduction of porosity by mechanical compaction was more significant than by cementation. Eodiagenesis mainly includes (1) mechanical compaction and mechanically infiltrated clays; (2) cementation by calcite, pyrite, and clay minerals; and (3) leaching of feldspars. Mesodiagenesis mainly includes (1) further mechanical compaction; (2) cementation by late stage carbonates; (2) formation of illite and mixed-layered illitesmectite; (3) quartz cements; (4) dissolution of feldspars. The porosity was decreased by compaction and cementation and then increased by dissolution of the framework grains. Primary porosity is higher in sandstones with abundant detrital quartz. Secondary dissolution pores are mainly associated with those feldspar-rich samples. Sandstones which have undergone the most feldspar dissolution are the cleaner (abundant in both detrital quartz and feldspar), better sorted, and coarser-grained samples. Reservoir quality of Chang 7 tight oil reservoirs is also largely controlled by pore occluding cements. The composition and texture have played an important role on intergranular volume and subsequent diagenetic modifications of the Chang 7 tight oil reservoirs. Good quality reservoir intervals are characterized by finegrained, moderately-well sorted with high percentages of detrital quartz and feldspar but low content of detrital clay and cements. The research has implications for the tight oil exploration in Ordos basin as well as scientific significance in tight oil reservoirs elsewhere.

A 3000 YR PALEOSEISMOLOGICAL HISTORY OF THE CENTRAL EAST ANATOLIAN FAULT (TURKEY) BASED ON SEDIMENTARY RECORD OF HAZAR LAKE

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The East Anatolian Fault (EAF) is a major left-lateral strike-slip fault accommodating with the conjugate North Anatolian Fault the westward extrusion of the Anatolian Plate away from the Arabia-Eurasia collision zone. During the 20th century, the EAF activity was mostly quiescent with only two events of magnitude greater than 6 recorded (1905 Malatya and the 1971 Bingol earthquakes). Historical seismicity suggests that the EAF is capable of generating earthquakes of magnitude greater than 7. In order to retrace the seismic history of the EAF in its central part, we study Hazar Lake. Hazar Lake is a 20 km long pull-apart basin with a maximum depth of 216 m. Short cores and long sediment cores were collected at four different sites to retrieve a paleoseismological record. Detailed analysis of the sediment cores (e.g. magnetic susceptibility, XRF, XRD, thin sections) were performed to identify sedimentary events. In total, 65 radiocarbon dating were done on bulk sediment and on terrestrial organic matter. The ages of the sedimentary events were inferred based on a detailed age-depth model combining radiocarbon dating and $^{137}Cs/^{210}Pb$. The results show that Hazar Lake region was impacted by two fault zones: The East Anatolian Fault and the North Anatolian Fault. Based on historical documents, the seismic intensity of each seismic event recorded in Hazar Lake was calculated. Here, we discuss the seismic threshold for earthquake records as well as the seismic recurrence pattern for the EAF over the last 3000 years.

SEARCHING FOR GREAT EARTHQUAKE RECORDS FROM RUPTURE OF THE HIKURANGI SUBDUCTION PLATE INTERFACE USING TURBIDITE PALEOSEISMOLOGY

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The 1000 km-long Hikurangi subduction margin, where the Pacific plate subducts beneath the North Island of New Zealand, is the country's largest earthquake and tsunami hazard. The seismic behaviour of the subduction interface includes interseismic coupling on the subduction thrust and the occurrence of slowslip events. The potential hazard, however is largely unknown because of the short (< 170 years) historical record of seismicity relative to the likely recurrence of great earthquakes. Marine turbidite paleoseismology provides a means to build long-term event records.

We first used a series of deep sediment cores collected along the 200 km-long northern section of the Hikurangi Margin. Stacks of cm-thick turbidites, interbedded with hemipelagite and tephra beds, provide great potential for age control through radiocarbon dating and chronostratigraphy. Core correlations across the northern margin using similarities in sedimentary facies, lithostratigraphy, physical properties and ages indicate the synchronicity of 19 turbidites since 7500 yr BP. Analyses indicate that 17 are the distal expression of synchronous earthquake-triggered submarine landslides that occurred on the continental slope. This paleo-earthquake record includes events from the upper plate and the plate interface. Empirical relations that combine Peak Ground Acceleration and earthquake characteristics helped us to deduce the earthquake's source and magnitude. Compared to the present active fault catalogue, this approach identifies 17 synchronous turbidites deposited from 390±170 to 7480±120 yr BP which recorded the rupture of three active faults, including the subduction interface, all triggered by earthquakes ≥ Mw 7.3. The temporal distribution of events suggests an erratic tectonic regime of the subduction interface with periods of high earthquake frequencies and periods of low earthquakes frequencies.

In November 2016, an RV Tangaroa voyage acquired 50 sediment cores (< ~5.5 m) along the southern half of the Hikurangi Margin. Sites were selected using multibeam bathymetric and backscatter data, sub-bottom profiles, archived sediment samples, and results from numerical modelling of turbidity currents. Sites fell into three categories: turbidite distributary systems; small isolated slope-basins; and Hikurangi Channel, levees and basin floor. Typical of the margin, the terrigenous-dominated sequence included layers of gravel, sand, mud and volcanic ash. Some cores contain up to 25 individual turbidites, potentially earthquake-triggered. This library of turbidites provides the basis of extending the paleoseismic records to the entire Hikurangi Margin.

Strong ground shaking beneath the NE South Island associated with the 14th November 2016 (NZDT) Mw 7.8 Kaikoura Earthquake occurred during the voyage. Within five days of the earthquake, we recovered with a multicorer what appeared to be a very recently emplaced co-seismic turbidite about 10-20 cm thick over a region extending c. 300 km from the Kaikoura coast. This offers a rare opportunity to calibrate paleoseismic data and to test hypotheses of turbidite triggering and emplacement. Analysis of the five cores that detected this highly fluidised layer overlying the pre-earthquake seabed clearly visible as an oxidised layer is ongoing.

Integrating earthquake records along the entire margin will be critical to single out events sourced from the plate interface from the large number of those from the upper plate.

CLIMATE CONTROL OF SEDIMENT PROVENANCE IN THE SOUTHERN ALPS OF NEW ZEALAND: NEW OBSERVATIONS FROM DETRITAL APATITE FISSION-TRACK TRACER THERMOCHRONOLOGY

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The production and discharge of continental sediment to ocean basins is a fundamental control on the global geochemical cycles that modulate the climate and habitability of Earth. Robust interpretation of the interdependencies between continental erosion and high-frequency climate change, including discriminating causality, requires robust explanations of the erosional processes generating sediment and transport processes delivering sediment to ocean basins. Global compilation of bedrock thermochronology data demonstrates the importance of cyclic glaciation on Pleistocene mountain exhumation, however the degree to which glaciation modulates the discharge of sediment to mountain-peripheral basins remains less comprehensively constrained.

We report a comprehensive detrital apatite fission-track thermochronology dataset that demonstrates sediment is non-uniformly sourced from six deglaciated catchments along the eastern flanks of the Southern Alps of New Zealand. Exploiting a monotonic relationship between apatite fission-track cooling age and distance across the orogen, we map the source of detrital cooling ages sampled from active river channels following a “tracer thermochronology” approach. In all six catchments, cooling ages are disproportionately derived from partially and fully unreset source rocks > 40 km from the Alpine Fault – the primary tectonic structure controlling mountain uplift Cooling age populations show no evidence to support a large contribution of sediment from the steep, high-relief and locally glaciated headwaters with the highest long-term rates of rock exhumation. Instead, our observations suggest that river sediment is locally derived, within 90 km drainage distance from the sample location for large rivers (Rakaia, Hurunui and Waimakariri rivers) and within ~40 km drainage distance from the sample location for the southern Tasman and Godley rivers.

Our observations of river sediment source contrast with provenance interpretations from continental margin silts, which instead suggest that late Pleistocene sediments were preferentially derived from river basin headwaters near the main drainage divide. We interpret this discrepancy as strong evidence for a climatically controlled binary sediment routing system where sediment is rapidly exported offshore during glacial periods yet abruptly slows during interglacial periods, accumulating in intermontane basins. Our observations broadly support the inference that the expansion of mountain glaciers may significantly increase global sediment discharge but highlight that this apparent increase may also result from a reduced offshore sediment flux if sediment is temporarily stored in intermontane basins during interglacial periods.

DYNAMIC ICE SHEETS DURING THE MARINOAN GLACIATION: EVIDENCE FROM THE NANTUO FORMATION IN THE YANGTZE BLOCK, SOUTH CHINA

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The Marinoan glaciation (~650 to 635 Ma) is the most severe icehouse event that our planet ever experienced. Geological and paleomagnetic evidences indicate that ice sheets have extended to low latitude areas during the Marinoan glaciation, inspiring a hard Snowball Earth hypothesis. On the contrary, climate model proposed that drawdown of atmospheric O_2 into the ocean owing to surface temperature decline would enhance the rate of dissolved organic matter remineralization in deep anoxic ocean, which would increase the atmospheric CO_2 concentration in turn and prevent a whole frozen Earth. Study of ice sheets dynamics may help understand the true situation of the Earth during Marinoan glaciation. Nantuo Formation in the Yangtze block of South China represents deposition during Marinoan glaciation. On the basis of detailed sedimentary observations of two field outcrops and two drill cores in Hubei and Guizhou Provinces, 10 lithofacies were identified in Nantuo Formation, including massive diamictite lithofacies, crudely stratified diamictite lithofacies, dropstone-bearing sandstone lithofacies, pebbly sandstone lithofacies, ripple marks siltstone lithofacies, conglomerate lithofacies, massive sandstone lithofacies, parallel bedding sandstone lithofacies, carbonate lithofacies and laminated mudstone/siltstone lithofacies. Guided by the glacial facies model, three facies associations were synthesized: proximal glacial marine facies association, distal glacial marine facies association and non-glacial marine facies association. Sedimentary logging indicates two glacial cycles in Nantuo Formation. The first ice sheet advance-retreat cycle was preserved in the lower part of Nantuo Formation. Reappearance of massive diamictite in the middle part of Nantuo successions indicate the onset of the second ice sheet advance-retreat cycle. These two glacial cycles were separated by > 10 meter thick of siltstone or shale which was deposited in a normal marine environments. Thin layer diamictite interbedded with siltstone in the uppermost Nantuo Formation might represent a return of a small scale glaciation during Marinoan meltdown. Lateral comparison of facies association imply the waxing and waning of ice sheets might be of global scale.

DISTRIBUTION OF FIBROUS CALCITE VEINS (BEEF) WITHIN SOURCE ROCKS. CASE STUDY: VACA MUERTA FORMATION, NEUQUÉN BASIN

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Bedding-parallel fibrous calcite veins (beef) are common in sedimentary basins, although preferentially found within petroleum source. The process of beef formation is commonly associated with the development of fluid overpressures and hydraulic fracturing in very low-permeability sediments. These veins consist of natural hydraulic fractures filled by antitaxial calcite fibres. In the Neuquén Basin (Argentina), beef frequently occurs in the deep-marine mudstones of the Vaca Muerta Formation (VMF) which is the main source rock of the basin. In the VMF, beef appears to be non-randomly distributed through the sedimentary record, our research work was therefore to investigate the parameters controlling their distribution.

The VMF was logged at millimeter-scale using sedimentary cores (650 m in total) from ten different wells. The core data was based on (1) the shale maturity range, from Ro=0.73 % to Ro=1.83 %; (2) the spatial location from the main thrust front; (3) the availability of compositional (mineral and organic) and petrophysical data.

Two main beef facies were considered (1) The "massive beef" facies, continuous at the scale of the core and defined by fibrous calcite veins containing a median zone and ranging from few millimetres to several centimetres thick and (2) the "micro discontinuous beef" facies which characterised by few millimetre-thick fibrous calcite veins. Both beef facies are not randomly distributed through the VMF. In particular, higher beef concentration is noticed at the base of the Formation. Also beef occurs mostly at facies interfaces and cluster mainly at the contact of calcareous concretions and volcanic ashes (75% of the total beef amount).

Beef is composed of fibrous calcite minerals and is the result of an antitaxial growth. Beef thinsections were studied using natural and polarized light and cathodoluminescence, showing that beef generation results from several phases of calcite crystallization that mineralized through time. Solid and liquid organic matter (bitumen and oil respectively) as well as aqueous fluid inclusions were also observed in most of the studied beef, indicating that the beef crystallization occurred when the source rock was already generating hydrocarbons.

Regarding organic matter content in the VMF, we identified a correlation between the beef occurrence and the total organic content (TOC) values. The TOC values range from 1% to 15% through the different cores, averaging at 4-5%. All the beefs are located in facies having TOC values higher than 2%, although micro-beef form in mudstones characterized by very high TOC values. This is a strong indication of link between TOC and beef distribution and thus would indicate that hydrocarbon generation and the resulting pressure increase may have played a key role in the generation of beef.

Our study also led to the observation that the number and thickness of beef increase with the maturity of the studied cores, i.e. there are more beef in mature to overmature areas than in lower mature areas. This points the role of the hydrocarbon generation in beef generation.

FOSSIL CONTOURITES CARBONATE DEPOSITS IN THE CHALK OF THE PARIS BASIN NORTHERN FRANCE, COMBINED BIOGENIC AND CONTOUR CURRENTS CONTROL

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The occurrence of contour-currents deposits within European Upper Cretaceous Chalk have been, though recently, widely demonstrated, particularly in the North Sea, through seismic imaging. However outcrop studies are still rare and do not allow recognition of geometries nor facies content. An exception is Denmark bryozoan mounds, where combined effects of biogenic growth and slope parallel bottom currents are evidenced. Normandy cliffs (northern France) are outstanding chalk outcrop, up to 100 m high and 100 km length that display exceptional conditions of observation from detailed facies to hectometric scale through large scale panoramas. Lenticular geometries with wavelength of x100 m to 1 km were firstly interpreted as bryozoan mudmounds, then as erosive bottom current and then as contourite sediment waves-like deposits. This study is based on multiscale outcrops characterization, from kilometer scale panoramas to thin sections in order to propose a multiscale facies and geometric model of these prominent geometries. This approach aims at recompose the dynamics of construction of these geometries, and the respective influences the hydrodynamics and carbonate production on their evolution. Their 3D geometry is recomposed by outcrop studies as well as basement observations and high resolution seismic data.

3D geometries are mostly mound-like features, all elongated along the same directions and separated from each other by through corresponding to more or less channelized intervals. 2 successives geometries are observed the first with hectometer scale mounds, the second with larger scale geometries separated by kilometer wide channel like features. Channels are all orientated parallel to palaeogeographic lines, demonstrating the predominance of contour currents.

All mounds display recurrent geometries and facies distributions that allow the proposition of a facies/ geometry model of these deposits. They reveal two successive phases: a progressive build-up phase followed by a progressive infilling phase. Benthic fauna distribution is clearly different, bryozoan dominated during build-up stage, echinid dominated during infilling stage. Asymetric geometries and facies distribution reveal lateral variations in current velocities with more or less channelized currents between mounds.

Our results demonstrate a combined influence of biogenic and hydrodynamics. Biogenic stabilization of sediments is more pronounced in the first stage. Geometries build-up is starting as small symmetric bryozoan rich mounds. They progressively evolve to asymmetric mounds where bryozoans are still abundant but more reworked, revealing stronger influence of bottom currents that can be noticed through facies distribution and development of asymmetric mounds with a by-pass flank and a gentler flank where accumulation occurs. At the transition between the build-up and infilling phases are the coarsest, most sorted deposits, associated with hardgrounds, revealing high current velocities with winnowing and by-pass. This transition is marked by a sharp change of benthic faunas, bryozoan being replaced by echinids. Within the infilling phase, progressive waning of current is revealed by finer grained and less sorted deposits upward. Above these deposits, channelization can lead to kilometer scale geometries where biogenic influence is less expressed. This study evidence illustrates strong interaction between benthic activity and contour current and proposes facies model for part of the contour current deposits in chalk.

SEDIMENT ROUTING AND PIEMONT DYNAMICS IN SYN OROGENIC SERIES OF THE AQUITAINE BASIN PYRENEAN RETROFORELAND (SW FRANCE)

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The Tertiary evolution of the Aquitaine basin (northern Pyrenean foreland) is closely linked to the Pyrenean orogeny and its northern retrowedge. During the Middle Eocene paroxysm of Iberia-Eurasia collision (Ypresian-Bartonian) strong denudation of the mountain belt takes place, partly compensated by the subsidence of the foreland. In the Aquitaine basin, this period is registered by the quick transition from dominantly marine underfilled sedimentation to continental overfilled sedimentation. In the proximal part of this system (piedmont), this overfilling leads to a massive, kilometer thick, conglomeratic sedimentation while deltaic sedimentation progressively fill the basin from east to west. Our aim is to document the evolution of denudation and sediment transfer during this syn-orogenic period and its relationship to orogenic prism dynamics, climate and transfer zone behavior. The dynamics of sedimentary and transfer processes is studied thanks to the S2S project (Total-BRGM). First results have been collected during RGF (BRGM) and Gaia (TIGF/BRGM/ AEAG) research programs.

This study has focused on the proximal part of this system in order to characterize (1) the dynamics of the piedmont sedimentation and its relation to tectonics, climate and denudation of the orogen, and (2) the transfer of sediments from the piedmont towards marine sedimentation. Field study of the synorogenic Palassou conglomerates and molasses de Carcassonne in eastern Pyrenees has been coupled with interpretation of subsurface data (well logs and seismic profiles).

The Ypresian – Late Bartonian system is organized along two main megasequences:

- The first sequence displays a continued progradation from shallow deltas to fluvial and lacustrine deposits and then locally to alluvial fans deposits. Fans are still relatively small. Clasts are mainly composed of meso-cenozoic superficial cover. This prograding trend is contemporaneous with the onset of thrusting in the foreland. The following retrograding trend is recorded by a return to relatively distal floodplain to lacustrine deposits.
- The second megasequence displays a major progradation with large scale plurikilometric alluvial fans emplacement and generalized fluvial sedimentation in the foreland. Within this sequence clasts are of very diverse origins with abundant clasts derived from the axial zone of the Pyrenees.
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The two sequences display significantly different geometries and facies that we correlate to different stage of evolution of the orogenic prism. We suggest that the large size and more diverse composition of the clasts in sequence 2 reveals important growth of the orogenic prism compared to sequence 1. Differences are also noticed in the marine record which suggest higher transfer to marine area during sequence 1 that during sequence 2. The parameters that trigger the differences in the piedmont dynamics are questioned and tentatively related to the mountain belt dynamics and climate evolution. The differences within the transfer capacities are probably linked to a growing size of the transfer zone that progressively buffer the sediment transfer to marine areas. A coupling with thermochronology and refined datations are under progress and will help to better constrain the schedule of sedimentary processes.

UPPER CRETACEOUS PALEOGENE SEDIMENTARY RECORD OF THE PYRENEAN RETROFORELAND (AQUITAIN BASIN). DEFORMATIONS AND SEDIMENT DYNAMICS

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The southern foreland (proforeland) of the Pyrenean orogeny is one of the most well-known foreland in the world, on the opposite its northern retroforeland (i.e the Aquitaine basin) which display a quite different tectonic style is less documented apart from local petroleum studies. Strong efforts have been made in the recent years to improve the knowledge of the Pyrenean orogeny and Aquitaine basin. We present here a synthesis of the Aquitain basin evolution during Upper Cretaceous and Paleogene based on the integration of more than 1000 wells and 5000 km of seismic profiles. A harmonized and detailed litho-and sequence stratigraphy was build up for the entire period allowing to recompose large scale sections, thickness and facies map at the scale of 1 My, and sedimentary response to compressive deformation. The distribution, style and timing of deformation of the retroforeland are precised thanks to refined stratigraphic constraints.

Within Cenozoic, five major tecto-sedimentary cycles are identified:

2 Paleocene cycles: A Danian-Selandian cycle (P1), and a Thanetian cycle (P2), both characterized by carbonate plat-form growth and limited compressive deformations.

3 Eocene cycles: An Ypresian-Lower Lutetian cycle (E1) composed of prograding deltas from east to west that redistribute material coming from the emerging mountain belt in eastern Pyrenees. This progradation trend leads to relatively quick infilling of the available space and emersion of a large part of the basin.

A Lutetian-Bartonian cycle (E2) composed of mixed carbonate siliciclastic deposits.

A Priabonian cycle (E3) marked by a large scale emersion of the basin and deposition of fined-grained continental sedimentation (Molasses d'Aquitaine).

The timing of deformation is refined and confirms (1) the onset of compressive deformations during upper Cretaceous, (2) the occurrence of a relatively quiet period during Paleocene (Danian-Lower Thanetian), and (3) a major period of basin deformation during Eocene. Within the basin, compressive deformations take place at both basin and local scale, the latter being mainly recorded as reactivation of inherited extensive faulting dating from Albian and /or late Variscan extension.

Within Eocene, two periods of deformation corresponding with the two successive tecto-sedimentary cycles (E1 and E2) are identified. Onset of compressive deformations is diachronous from east to west.

Early Eocene deformations mainly take place in the eastern and central part of the basin, with renewed deformations around Paleocene-Eocene boundary, coeval with the onset of terrigenous input from the growing mountain belt, and major pulse by Upper Ypresian. Late Lutetian-Early Bartonian deformations during cycle E2 are recorded throughout the basin and trigger major depocenter shifts.

Together with the well known timing of the southern Pyrenean foreland deformations these data yields numerous constraints about the Pyrenean orogenic prism evolution.

Acknowledgments: These results were acquired during the Gaia project founded by TIGF, BRGM and Agence de l'Eau Adour/Garonne which aims to constrain the nature and dynamics of deep Upper cretaceous and Tertiary aquifers of the Aquitaine basin.

SEISMIC VALVE AS THE MAIN MECHANISM FOR SEDIMENTARY FLUID ENTRAPMENT WITHIN EXTENSIONAL BASIN: EXAMPLE OF THE LODÈVE PERMIAN BASIN (HÉRAULT)

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During basin burial, interstitial fluids initially trapped within the sedimentary pile are easily moving under overpressure gradient. They have a significant role on deformation during basin evolution, particularly on fault reactivation, and their precipitation forms Mississippi Valley-type ore deposits.

The Lodève Permian Basin (Hérault, France) is an exhumed half-graben with exceptional outcrop conditions providing access to barite-sulfides mineralized systems and hydrocarbon trapped into syn-rift rollover faults and paleokarst features. Architectural studies show a cyclic infilling of fault zones and associated bedding-parallel veins according to three main fluid events during dextral/normal faulting. Contrasting fluid entrapment conditions are then deduced from a textural analysis, fluid inclusion microbarothermometry and barite-chalcopyrite sulfur isotope thermometer. We conclude that a polyphase history of sedimentary fluid trapping occurred during Permian syn-rift formation of the basin:

(i) The first stage is characterized by an implosion breccia cemented by silicifications and barite during an abrupt pressure drop within fault zone. This mechanism is linked to the dextral strike-slip motion on faults and contribute to a first sealing of the fault zone by basinal fluid mineralization.

(ii) The second stage consists in the succession of barite ribbons precipitated under overpressure fluctuations between suprahydrostatic and sublithostatic pressure conditions. This corresponds to periodic reactivations of fault planes derived from fault-valve action and localized at sulphide-rich shearing structures showing normal movement. Because the ascending fluids in fault zone reached the lithostatic pressure, it leads to the vertical opening of stratabound joints developing meter-scale bedding-parallel veins.

(iii) The last stage is associated with the formation of dextral strike-slip pull-apart infilling by large barite and contemporaneous hydrocarbons under suprahydrostatic pressure values. This final tectonic activation of fault is linked to late basinal fluids and hydrocarbon migration during which shear stress restoration on fault plane is faster than fluid pressure build-up.

This integrated study presents a coherent scenario which helps to link far and local stress during the syn-tectonic sedimentation of a basin with basinal fluid overpressure, opening mode of drain and mineralization processes. Fluid-assisted fault reactivation and related deformation of the sedimentary pile clearly impact potential economic reservoir as late metal-rich fluids are associated with hydrocarbon migration during burial.

A SOURCE-TO-SINK APPROACH OF THE CONGO SYSTEM SINCE 200 KA. PART I: 3D STRATIGRAPHIC FORWARD MODELING OF THE DEEP-SEA FAN USING DIONISOSFLOW

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Deep-sea fans are governed by a complex interaction between numerous forcings, whether internal (topographic compensation, dynamics of turbidity currents...) or extra-basinal (tectonics, sea level, climate). However, the relative impact of such controlling parameters remains under debate, mainly due to the difficulty in individualizing factors responsible for a particular stratigraphic evolution.

The geometry of the Late Quaternary Congo Fan is characterized by successive prograding/retrograding cycles of depocenters reflecting a periodic control of sedimentation. A multi-proxy study revealed a strong interplay between autogenic control and climate forcing as evidenced by changes in sediment supplies reaching the fan consistent with arid and humid periods. The aim of this study is to simulate and investigate factors of sedimentation in the Congo Fan since 200 ka through a 3D forward stratigraphic modeling using DionisosFlow© (IFP-EN), a diffusion process-based software. It allows the 3D geometry reproduction of sedimentary units from deltaic to deep-sea environments, based on sea level changes, tectonics, sediment supply and transport. In our study, evolution of water flow, sediment yield and sand/shale ratio are exclusively extrapolated from marine proxies. At the end, simulation results are calibrated based on sedimentary facies distribution and volume of deposits inferred from core and seismic data (CougarFlow©).

According to modeling results, periodic variations of sediment production and water flow represent the only control on the timing, position and volume of prograding/retrograding cycles. Best-fit simulations show that the overriding factor responsible for such changes is the expansion of vegetation cover in the catchment basin, in close relationship with the intensity of precession-driven West African Monsoon. The vegetation/climate coupling thus acts directly on the transport capacity of turbidity flow through time by controlling river runoff magnitude and timing of sediment production, storage and transfer from continent to ocean. We conclude that a three-step model characterized the architectural evolution of this fan with a maximal progradation of depocenters during wetter periods, an aggradation/retrogradation phase during arid epochs and finally a very upfan avulsion at arid/humid transitions. Additionally, at each stage, a steep increase of the sand/mud ratio, linked to abrupt destabilizations of river mouth bars, can lead to the development of mid-fan avulsions.

This study first confirms the relevance of stratigraphic diffusion process-based model to constrain the architectural evolution of submarine fans at basin scale. In fine, such method allows us to propose a 4D "source to sink" model of the Late Quaternary Congo Fan development which emphasizes the strong impact of drainage basin responses to climate change on sedimentary facies distribution and architectural elements in the deep-sea environment. The part II of this study is dedicated to the quantification of input fluxes by hydro-sedimentary modeling of the onshore domain, leading to additional stratigraphic simulations based on the paleoenvironmental history of the drainage basin (Molliex et al., this volume).

SPATIAL DISTRIBUTION OF DOLOMITISATION WITHIN A COMPLEX STRATIGRAPHY IN AN ISOLATED CARBONATE PLATFORM, BONAIRE, NETHERLANDS ANTILLES

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In contrast to the tectonically stable carbonate platforms of the Bahamas, in the southern Caribbean Neogene tectonic activity combined with fluctuations in eustatic sea-level and climate to generate a complex pattern of depositional and diagenetic geobodies. On the island of Bonaire three Neogene platforms have been identified, comprising a succession of shallow-water platform interior, margin and eolian deposits onlapping a topographically complex volcanic basement. These platforms have been subject to marine coastal erosion which has generated a series of five flat-topped terraces up to 120 m elevation which are bounded by steep former sea-cliffs. The oldest deposits comprise inclined calcitic bioclastic units of Middle Miocene age (comprising gastropods, green algae and bivalves fragments) and are restricted to the northwestern part of the island (Goto Meer). Onlapping this is a much more extensive Upper Miocene platform with a complex sequence of shoreline-lagoon and eolianite facies with flat geometries and shelf-margin clinoforms that prograded eastwards, following the regional tectonic trend. The youngest deposits are Pleistocene, dominated by reefal deposits, which outcrop in a rim around the island at an average elevation of c.9 meters above sealevel.

Field mapping, combined with digital outcrop models, has revealed that dolomitisation is considerably more extensive than previously recognized, and affects not only the older inclined beds at Goto Meer, but also the Upper Miocene deposits extending over much of the central and northern part. Our sections reveal preferential dolomitisation of the red algae-rich grainstone/packstones of the shallow water platform interior and margin deposits. The mostly non-stoichiometric calcian dolomite (Ca:Mg 55:45) is sucrosic with crystal size between 25 to 200 µm diameter, cloudy centers and local zoning. The stable isotope composition of the completely dolomitized red algae facies ($\delta^{13}C$ = +2 /+4 ‰ PDB and $\delta^{18}O$ = +1.5 /+5 ‰ PDB) suggests a marine evaporative origin. A reflux model is supported by detailed mapping of dolomite at the Seru Grandi outcrop, where there is a systematic reduction of dolomite abundance and crystal size along the clinoforms. In contrast, host limestones have very negative values both in carbon and oxygen isotopes ($\delta^{13}C$ = -4/ -8 ‰ PDB and $\delta^{18}O$ =-1 / -5 ‰ PDB) suggesting meteoric diagenesis. $^{87}Sr/^{86}Sr$ isotopes of Upper Miocene platform at Seru Grandi range between 0.708842 and 0.709035, contrasting with Middle Miocene deposits at Goto Meer that shows values of ~ 0708491. Also, Mn concentrations of Goto Meer show values up to ~650 ppm, contrasting with values < 100 ppm in our younger sections. The most recent Pleistocene deposits outcropping above sea-level show no dolomitisation, although reflux may be occurring at the present time in the Pekelmeer.

Bonaire provides a remarkable example of extensive island dolomitisation prior to burial. The presence of excellent outcrops in the island makes this location a natural laboratory to understand dolomitisation within a stratigraphically more complex setting than many previously studied.

ENVIRONMENTAL AND CLIMATE RECONSTRUCTION OF THE EOCENE/OLIGOCENE DEPOSITS FROM THE PARIS BASIN: CORMEILLES-EN-PARISIS SECTION (FRANCE)

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The Cormeilles-en-Parisis quarry (Val-d'Oise, France) is one of the largest open-mine for gypsum extraction in Europe. The quarry is currently in a rehabilitation process and only a little part of the front is actually accessible. The outcrop will unfortunately disappear in 2018, with the open activity ceasing in favor to an underground operating of the first mass of gypsum.

In this context, the ISTeP Laboratory has undertaken a new detailed study of the sedimentary deposits in cooperation with the Placoplatre Company, which allows us involved in this work to access the front and a bore-hole core. The integrative study includes new approaches such as magnetic susceptibility and SEM observations.

The quarry shows a wide and complete stratigraphic deposits range between Priabonian (Ludian– Upper Eocene) and Rupelian (Stampian-Oligocene) which were the object of several sedimentological, paleontological and geochemical studies since the beginning of the previous century. The origin of the Ludian gypsum has been subject to controversy for several decades. Marine water supply or continental sulfate solutions from the dissolution of Permo-Triassic evaporites (Eastern France) have been proposed.

A detail sedimentological analysis of the outcrops in quarry from the "Marnes à Lucines" layers to the "Sables de Fontainebleau" have been completed by the drilling study ("Seconde masse de gypse" to "Sable de Fontainebleau"). Based on the previous works of Soyer (1939), Cavelier (1964) and Fontes (1969), the main objectives of this study are first to precise the lithological, mineralogical and geochemical composition of the sedimentary deposits. Second, paleoenvironmental reconstruction is proposed and a climatic control versus tectonic or erosion of deposition is discussed using detailed observations and characterization of the facies by optical microscopy, SEM, X-ray diffraction and magnetic susceptibility.

First results: the lower part of the section ("Marnes à Lucines" up to "Marnes entre-deux masses") shows more magnesian conditions with palygorskite and sepiolite associated to gypsum, iron carbonates (siderite) and quartz neogenesis. Magnetic susceptibility data are high even in the second gypsum level. These observations could reflect a mixt between marine and continental (palustrine) water solutions. The "Première masse de gypse" is homogeneous, only composed of gypsum and is diamagnetic. Several granulometric sequences of saccharoïd gypsum are observed. A primary solution from an older reworked gypsum deposits can be proposed. The post gypsum layers show progressive environmental change in the "Marnes Bleues d'Argenteuil", with more continental detrital supply composed of 5 depositional sequences with first illite and quartz compounds and in the upper part with also kaolinite.

More humid climate is observed except in the "Marabet" and "Glaises à Cyrènes" Formations (Eocene / Oligocene boundary) where gypsum, dolomite, palygorskite and sepiolite are observed. In the upper part of the outcrop, the "Calcaire de Sannois" is enriched in magnesian clays and could record new confined conditions.

STABLE ISOTOPIC APPROACH ON MOLLUSK SHELLS TO PALEOENVIRONMENTAL RECONSTITUTION: STUDY OF AN URBAN SITE: LYON (FRANCE)

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Since Antiquity, the human settlement and the development of the city of Lyon were controlled by the topography, and were linked to the Saone and Rhône rivers activities. The Rhône discharge is influenced by Alpine glaciers whereas the Saone is characterized by rainfall regime. The fluvial changes do not reach an amplitude as great as that of climatic events for the latter.

At the foundation of Lugdunum (43 BC), the fluvial activity was high with frequent floods. The extension of the city was mainly located on the Fourvière heights. Later, due to a decrease of the hydrological activity of the rivers (around 0 AD), the city increased on the Saone river valley and on the peninsula.

During their growth period, malacological fauna shells potentially record the impact of major hydrological and climatic changes on the aquatic ecosystem. To improve the isotopic (carbon and oxygen) record of the freshwater mollusks as a riverine and paleoenvironmental proxy, we have studied bivalves and a few gastropods collected in anthropogenic soils and river sediments.

The study is focused on two well-known climatic extremes: the Medieval Climate Optimum (X-XIth centuries) and the Little Ice Age (XVIth and XVIIIth centuries). A third less documented period corresponds to Antiquity (II-IIIrd centuries). The shells studied were collected on: the peninsula, for Antiquity: near the left bank of the Saone river (*Théâtre des Célestins*) and close to the old confluence area (Hôtel Cuzieu: Sainte Hélène Street and Auguste Comte street); for the LIA (XVIth century), near the right bank of the Rhône river (*Hôtel Dieu*).the hill of Fourvière on the right bank of the Saone, for the Middle Ages (X-XIth centuries) and the LIA (Monseigneur Lavarenne street).

The aragonite mineralogy and structure of the shells are well preserved. The $\delta^{18}O$ and $\delta^{13}C$ values are close to the isotopic signature of the modern Saone water, modern mollusk shells and ratios calculated for aragonite precipitated in isotopic equilibrium with the river. A privileged use of the alluvial deposits of this river by human activity can be proposed.

No obvious significant $\delta^{18}O$ change (between- 7 and -8 ‰) is observed for either of the three studied periods. This could be due to the lowland-dominated hydrological regime of the river.

In detail, temperatures of shell secretion can be estimated using oxygen isotope composition of the modern and local river water (for March, July and September 1996). An average paleotemperatures difference of the waters about 2°C may be proposed between the MCO and the LIA. Shells from Antiquity may record intermediate temperatures.

The range of $\delta^{13}C$ is wide, between -13.4 and -10.8‰. The important data fluctuation for the Antiquity shells may reflect the geomorphological configuration of the peninsula at this period, showing depressed lone set on paleochannels of the Rhone system. Data set of the Middle Ages shells is very stable and negative corresponding to more favorable climatic period (warming and decreasing flows) with pedogenesis and enriched organic matter banks.

THE SEDIMENTARY ROCK RECORD OF MARS AS VIEWED FROM THE LAST DECADE OF ORBITAL MISSIONS

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Over the last decade, orbital and landed missions have revealed a diverse and extensive sedimentary rock record on Mars. In the absence of plate tectonics, and because of a decline of the geological activity over time, the Martian sedimentary record is well-preserved and much older than terrestrial records. Both clastic and chemical sedimentary rocks occur on Mars, in a wide range of depositional environments. In addition to the expected impact-and volcanically-generated deposits, some sedimentary rocks were formed and deposited in local aqueous environments, i.e., alluvial, fluvial, deltaic, and lacustrine environments. Interestingly, clays are the most common and widespread alteration minerals on Mars. They have been detected by orbital visible and near-infrared spectroscopy in association with sedimentary rocks, supporting intense past chemical weathering under circum-neutral pH conditions. Therefore, more clement conditions have likely prevailed during the first billion years on Mars. Some regionally extensive sedimentary formations with thicknesses of up to several kilometers cover plateaus and fill canyons and other closed basins in the equatorial regions of Mars. Containing a variety of sulfates, iron oxides, amorphous silica, sometimes interbedded with clays, their origin is still under debate but likely results from multiple formation processes including lacustrine evaporation, groundwater alteration, hydrothermalism, and eolian reworking. Numerous exposures of chloride-bearing deposits show the existence of ancient ponding of brines. The mid-latitudes regions of Mars show a variety of ice-related deposits including lobate debris aprons, lineated valley fill and concentric crater fill. Sulfate-bearing sands in the polar regions are inferred to have formed by weathering of dust particles within ancient massive ice deposits. This presentation will provide an overview of those sedimentary formations as seen from orbital observations, and will discuss the implications on the geologic and climatic evolution of Mars.

SEDIMENTS ON TITAN

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Like on the Earth, Mars and Venus, the production, transport and deposition of sediments occur on Saturn's biggest moon Titan. The Cassini-Huygens mission has indeed revealed that Titan harbors vast reservoirs of low-density, non-silicate granular materials. This sand covers an extensive portion of Titan's equatorial belt where it is organized in linear dunes by winds. At higher latitudes, mournful plains substitute to dunes maybe because the sand grains are more cohesive due to a higher surface humidity. Based on its near-infrared spectra and microwave emissivities, Titan's sand is mostly organic in nature; it was probably produced by the erosion of layer formed by the deposition and accumulation of the products of Titan's atmosphere intense photochemistry. Pebble-like sediments were also observed at the Huygens landing site and probably strewn the bed of most of Titan's dry fluviatile networks. Aeolian and fluvial (with liquid methane and/or ethane) processes are most likely the most significant mecanisms for large-scale sediment transport on Titan; they sculpt, in this cold world (the temperature is -180°C), landscapes that are very familiar to those we observe on the Earth. In this paper, we will give an overview of the sedimentology on Titan showing, in particular, how it relates to the moon climate.

ANCIENT CARBONATE SLOPE SYSTEMS: AN EXAMPLE FROM THE LATE CRETACEOUS OF ALBANIA

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The Upper Cretaceous deposits of the Ionian Basin expose a unique example of a carbonate re-sedimentation system, now incorporated within the Albanian structural fold-and-thrust belt. Originally developed along a NW-SE direction extending into Greece, the Ionian Basin underwent shortening that resulted in the stacking of SW-verging thrust belts, now extensively exposing the Mesozoic succession. The Upper Cretaceous interval reveals a wide range of re-sedimentation facies of carbonate material derived from the Apulian Platform in the west. Two particular outcrops, Ksamil and Muzina, which belong to two separate thrust belts, are reported here. They respectively reveal the proximal and distal setting of the carbonate slope that forms the eastern edge of Apulia.

The Ksamil outcrop encompasses polygenic conglomerate beds of 5-15 m thick, composed of poorly sorted carbonate clasts in a calcilutitic matrix. Platform and slope-derived lithified clasts suggest dismantling of the platform and erosion of the slope. Recent investigations revealed significant variability in bed thickness and erosional contacts with underlying fine-grained (calcilutitic) series, pointing to the development of furrows expanding towards the basin.

The Muzina outcrop reveals graded calcarenite beds (0.5-2 m thick) that document well-defined normal grading over the entire thickness of the bed. Alternations of planar-horizontal and low-angle laminations within the calcarenitic material were recognized. The uppermost part of beds exposes calcarenite-rich load-casts and convolute laminations grading upwards into calcilutites, which are commonly associated with in-situ chert layers at the top. These deposits typically adopt sheet-like morphologies with no evidence of erosion.

Field observations form an integral part of this study, comprising facies and geometrical characterizations in the Ksamil outcrop and bed tracing along the kilometer-scale Muzina outcrop. In addition, numerous thin sections were analyzed. Previous studies have constrained the framework of the Late Cretaceous sedimentary evolution in this region. However, the down-slope evolution of single-bed gravity-flow events, as well as sedimentary attributes of the slope system as a whole, still need to be unraveled. This contribution aims to discuss how such uncertainties related to carbonate slope systems can be resolved.

COMPARING MASS TRANSPORT DEPOSITS IN LARGE-SCALE FOSSIL AND MODERN CARBONATE SYSTEMS

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Mass-failures in large-scale carbonate systems result in Mass Transport Deposits (MTDs) commonly made up of significant amounts of sediments (1-1000km^3). These volumes represent considerable issues regarding the stability of sea floor infrastructures, as well as promising reservoir targets. However, the controlling factors of downslope transport of unlithified sediments and the architecture of MTDs are still poorly understood. Sliding and slumping are two mechanisms in which extensive downslope sediment transport takes place; they either result in gradual transitions with poorly detectable amplitude of movement when sliding or chaotic patterns when slumping in outcrop or in seismic data. However, a detailed analysis of the distribution of deformational structures provides information on: a) the size and geometry of slides/ slumps; b) extensional, compressional and strike-slip structures associated with downslope transport.

Recent studies on the modern Bahamian carbonate system show kilometer-scale failure scars rooted at the slope. The carbonate succession at the toe of slope typically shows an alternation of packages with continuous reflectors and discrete intervals exposing low-amplitude discontinuous and chaotic reflections. Latter might be explained by the fact that the architecture of slides/slumps commonly falls beyond seismic resolution.

In South Albania, the Upper Cretaceous-Paleocene platform and slope/basin series outcrop extensively in three main thrust belts following a NNW-SSW orientation. The outcrops show a series of re-sedimented carbonate sedimentary successions. The platform domain is exposed in the East, in the Sazani Zone. Prominent MTDs have been evidenced on both platform and slope environments, and three distinctly deformed intervals could be correlated using bio-and chrono-stratigraphical analysis. The large-scale outcrops allow for precise mapping and accurate analysis of the syn-sedimentary deformation structures within each slide/slump interval. Failure planes and axial surfaces / hinge axis related to syn-sedimentary deformed beds were documented.

This study proposes an assessment of deformational patterns within MTDs in modern and fossil environments, with a special focus on the along-dip/strike variabilities as well as the volumes of the sediments involved.

DISTINGUISHING GLACIAL FROM NON-GLACIAL DIAMICTITES IN THE ANCIENT RECORD: SOME CRYOGENIAN EXAMPLES

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Understanding the origin of poorly sorted materials is critical in the ancient record since many diamictites have been allied to a glacial origin, and hence great palaeoclimatic significance is placed upon them. Nowhere is this truer that in the Cryogenian record, where glaciation and rifting operated in tandem on many continents. Using examples from the Kingston Peak Formation of Death Valley, California, area, we illustrate two points pertaining to the origin of Cryogenian diamictites. The first is that in the Silurian Hills, diamictites of true glacial origin mirror dropstones in terms of lithologies, reflecting the "glacial conveyor belt" system that transported materials over long distances. The diamictites allied to slope collapse, meanwhile, are typically characterised by irregularly shaped sedimentary megaclasts produced through slope foundering. The second key point is that diamictites interpreted as deposits of the Marinoan glaciation were instead produced through collapse of a carbonate platform system, because they contain various facies considered unique to cap carbonates (tubestones, abiotic laminites etc). This second point reinforces the cap carbonate platform model of Creveling et al. (2016) wherein slope canyons shed poorly sorted material downslope during collapse events. Textural analysis of diamictites toward the top of the Kingston Peak Formation from multiple outcrop belts (Kingston Range, Alexander Hills, Saddle Peak Hills, Panamint Range) illustrates how readily such platform collapse breccias can be distinguished from true glaciogenic debris flow (GDF) deposits in underlying strata. The collapse breccias are characterised by sub-angular to angular clasts, with rod-shaped and highly irregular clast shapes being typical, to the exclusion of striated clasts, dropstone textures in interbedded fine-grained deposits, which by contrast are typical in glaciogenic intervals. These interpretations lead us to place far less significance on the global correlation value of diamictite intervals than has been suggested by previous workers.

UPPER PLEISTOCENE EVOLUTION OF THE SOUTH WEST NEW CALEDONIA MIXED CARBONATE RIMMED SHELF

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Modern analogs offer the possibility to better understand sediment transfer along shelf-margin carbonate system and to depict the detailed sedimentary response of barrier-reef carbonate system to glacialinterglacial cycles. This response is susceptible to develop a very high degree of lateral and vertical facies heterogeneity in presence of terrigenous input interplaying with carbonate production. The lithofacies succession of such systems and related continental imprint are strongly controlled by amplitude, rate of sealevel changes, clastic inputs and sediment transfer processes. As pure siliciclastic margins, most of modern mixed carbonate rimmed shelves are characterized by paleo-drainage networks incised into lagoon floors. They are thought to be carved by extension of rivers during Pleistocene sea-level lowstands, thus delineating major pathways for water exchanges and axes for terrigenous sediment transfer to the deep margin. Nevertheless, the evolution of mixed carbonate-terrigenous shelf and the relative role of lagoon backfilling and paleo-drainage system in sediment transfer need to be better documented and constrained. The Upper Pleistocene evolution of New Caledonian (NC) barrier reef–lagoon complex offers the opportunity to complete this approach. Previous results revealed that rivers did not incise the inner NC shelf and suggest a decoupling of upland river systems and lagoonal channels propagating from barrier edge. In contrast, seismic lines exhibit locally a nearshore layered aggrading alluvial prism cut by numerous superficial channels. New data collected during the CALICO cruise performed in 2014 show that this continental wedge developed during the last glacial sea-level fall in front of coastal hills and located in a semi-enclosed lagoon depression at the mouth of continental valleys. Thus, even if terrigenous sediments were partly exported towards deep basinal areas during lowstand incision as suggested by channel lag deposits, the depression acts as a buffer zone and allows the preservation of a significant fraction of clastic material during subaerial exposure of the shelf. This sedimentary evolution differs from the classic model of reciprocal sedimentation of mixed terrigenous/ carbonate with lowstand shedding of clastics and lowstand wedges restricted to the margin slope and basin floor. Moreover, sediment rates computed for the marine Holocene cover are of the same order of magnitude of subsidence for a large part of the lagoon and argue for the relative steady state of semi-filled lagoon. It also means that Holocene marine sediment cover has preserved in many places the inherited morphogenesis acquired during lowstand sea-level or early transgression. Finally, the New Caledonian South West lagoon illustrates an example of very shallow rimmed shelf bounded by a very steep slope and corresponds to an "escarpment margin" type of carbonate platform. This morphology induces a reduction of barrier reef progradation and as a consequence platform facies are mainly built vertically and controlled by the inherited morphology.

SEDIMENTARY PROCESSES INTO FAULT-RELATED BASINS OFF WESTERN HAITI

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Understanding and identifying earthquakes cycles, as well as the magnitude and recurrence of earthquakes over a long term is still very complex. From the analysis of gravity deposits, marine paleo-seismology offers to identify and date old earthquakes over sedimentary archives, to establish an earthquake recurrence.

Fault-related basins of western Haïti are located in an active geodynamic context. The Wind basin is related to Northern Oriente fault and Navassa and Matley basins are located along the Enriquillo PlantainGarden fault. These basins have been studied for the first time with very high resolution seismic profiles and three sedimentary cores. Sedimentological analyses of cores to determine sedimentary processes and sources, are based on X-ray images of gravity deposits, X-ray fluorescence core scanner measurements, grain-size analyses, and petrographical obsevations under microscope. A biostratigraphical analysis completed with radiocarbon dates and $^{210}Pb_{exc}$ allowed to construct age models of these cores.

The main results indicate sedimentation rates ranging from 4 to 15 cm/ka into the southern basins (Navassa and Matley basins) and 5 m/ka into the northern basin (Wind basin). The southern basins are characterized by turbiditic processes with a few homogenite sequences, predominantly carbonated (pelagic material) whereas the northern basin istypically filled with terrigeneous homogenite sequences. The recurrence times between each deposit is ~1700 years for the Navassa basin and ~5800 years for the Matltey basin.

Sedimentation of these basins is governed by: (1) the sediment volume delivered to the basins, and (2) a greater tectonic activity along the Northern Oriente fault with regard to Enriquillo-Plantain-Garden fault.

SEDIMENT PROVENANCE OF THE CRETACEOUS SINDONG GROUP, GYEONGSANG BASIN, KOREA INFERRED FROM DETRITAL ZIRCON GEOCHRONOLOGY AND ITS IMPLICATIONS FOR PALEODRAINAGE

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The Lower Cretaceous Sindong Group in southeastern Korea is a fluvio-lacustrine sedimentary package deposited in an elongated basin (the Nakdong Trough) formed by extension in an active continental margin setting. To characterize the sedimentary provenance and paleodrainage system for the Sindong Group, sandstones from the middle part of each of the three stratigraphic units (the Nakdong, Hasandong, and Jinju formations in ascending order) in three different parts of the Nakdong Trough (northern, central, and southern parts) were collected for detrital zircon U–Pb dating using a laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) technique. Detrital zircons show a wide range of ages from 106 Ma to 3494 Ma with spatial and temporal variations in age population. Based on the Kolmogorov-Smirnoff (KS) statistical test, zircon-age populations can be grouped into three sample groups: (1) northern and central Nakdong sandstones, central and southern Hasandong sandstones, and central and southern Jinju sandstones, (2) northern Hasandong and northern Jinju sandstones, and (3) a southern Nakdong sandstone. Each of these three sample groups of the Sindong Group may represent respective provenance during the Nakdong Trough filling. Detrital zircon age spectra and paleocurrent data reveal that the Early Cretaceous river system was sourced from at least three drainage basins in the Yeongnam Massif. The drainage system for the central portion of the basin was consistent with time, whereas statistical treatment of the detrital zircon age populations using K-S tests confirms a provenance shift between the Nakdong Formation and Hasandong Formation in both the northern and southern portions of the Nakdong Trough. The subsequent paleodrainage system was replaced by source terranes composed mainly of Jurassic granitoids with minor Paleoproterozoic rocks in the northern portion and source terranes composed of rocks of mixed Paleoproterozoic, Mesoproterozoic, Neoproterozoic, and Early Cretaceous in age in the southern portion, respectively. The former was likely caused by strong influences resulting from confluence of dispersal path draining Jurassic granitoids, possibly aided by faulting activity, whereas the latter was caused by extension of the drainage basin to the source terrane having similar geology to or shared the source terrane for the paleoflow system for the central portion.

APPLICATION OF FACIES CONTROLLED GEOLOGICAL MODELING METHOD TO DESCRIPTION OF SHALLOW WATER DELTA FRONT SUB-FACIES

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The shallow water delta front sand system is characterized by shallow water, narrow channel and frequent water regression and invasion; the main channel of development in many different directions, the estuary dam is relatively undeveloped; lack of early deep channel deposits; the sedimentary structure of the distributary channel represents the sedimentary processes of fluvial and lacustrine. In the development process of water injection, the development characteristics of sedimentary micro-facies seriously affect the distribution of remaining oil, which brings difficulties for the understanding of the distribution law of remaining oil. Therefore, in the process of geological modeling, it is important to consider the restraint of sedimentary microfacies on reservoir distribution.

This paper analyzes the sedimentary characteristics of shallow water delta sub-facies, reservoir configuration and distribution law of single stage channel to summarized seven structural models of different river channels and two structural models in the river channel. Under the guidance of this model, the quantitative prediction of channel sand bodies is carried out by using the sedimentary features of modern shallow water delta. In the fine geological modeling process, combination of well and seismic, the multiple point geostatistics “training image” instead of “classical geostatistics variogram”, application of sequential indicator method to establishment the stochastic model of interlayer, coupled with the deterministic modeling model of single period channel, through grid replacement, the formation of fine configuration geological model under the control of sedimentary microfacies. The geological model established by this method can characterize the reservoir characteristics of shallow water delta front sub-facies. Model accuracy and reliability evaluation indicate that the configuration modeling of facies controlled can effectively reduce the uncertainty of reservoir characterization of shallow water delta front sub-facies, and significantly improve the simulation accuracy and operational efficiency of complex geometric shape and multi stage superimposed small channel. At the same time, the model is applied to reservoir numerical simulation, which is very helpful to improve the description accuracy of remaining oil.

ICE STREAM BEHAVIOR DURING DEGLACIATION CONTROLLED BY OUTBURST EVENTS AND TUNNEL VALLEY FORMATION: INSIGHTS FROM ANALOG MODELLING

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In order to understand the relationships between subglacial water drainage, tunnel valley formation and ice streams, we have conducted innovative experiments to monitor the ice flow dynamics and the development of both erosional and depositional features. In these analog experiments, the substratum and the ice are respectively simulated by sand and a silicon putty, while subglacial meltwater production is simulated using a punctual injection of water in the substratum. We placed markers at three levels (base, mid-thickness and surface) of the silicon putty and produced DEMs of the subglacial surface (using photogrammetry) to follow simultaneously the evolution of the subglacial drainage system, the ice flow dynamics and the formation of tunnel valleys. Knowing the silicon and the injection system characteristics, we here simulate a wet-based glacier experiencing intense melting that advances and thins through time, therefore reproducing a collapsing ice sheet during deglaciation.

We aim to describe the temporal relationships between (1) subglacial water storage, (2) outburst events, (3) tunnel valley formation, (4) evolution of the subglacial meltwater drainage efficiency and (5) ice stream dynamics in a context of deglaciation. The experiments show that a corridor of fast flowing-ice (flowing 20 times faster than the surrounding ice) is induced by the generation and migration of a subglacial water pocket at the ice-bed interface, illustrating an ice stream birth. The water pocket migrates until it suddenly drains when reaching the ice front, leading to an acceleration of the ice flow and the rapid deposition of a proglacial low-angle fan under sheet flow (i.e., outburst event). Once the water pocket is drained, meltwater produced subglacially flows through an efficient channelized drainage system composed of submarginal tunnel valleys. The formation of tunnel valleys is associated to the proglacial development of subaqueous ice-contact fans subject to hydraulic jump at the subglacial conduit outlets and whose surfaces are higher than the tunnel valley bases. Through time, tunnel valleys may become abandoned in favour of a new generation of tunnel valley that develops laterally. This change in tunnel valley dynamics is associated with a migration of the ice stream corridor related to subglacial water piracy mechanisms when the drainage inefficiency of the existing tunnel valley systems modifies the predominant meltwater route. Once the number and size of tunnel valleys are sufficient to drain efficiently the meltwater, subglacial overpressures decrease and the ice stream shuts down. Subglacial water storage, glacial outburst and tunnel valley formation appear to control the glacial dynamics and the evolution of sedimentary sequences deposited during deglaciation. In addition, we show that tunnel valleys are major components of the subglacial hydrological system that may counterbalance the collapsing dynamics by draining the meltwater excess responsible for ice flow speeding up.

SEDIMENTARY RECORD IN THE NORTHERN AFAR DEPRESSION (ETHIOPIA): WHAT MESSAGE FOR THE RIFTING DEVELOPMENT AND EROSION HISTORY?

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The Northern Afar, or Danakil, Depression is the only place in Afar where sediments are extensively preserved while in the south only magmatic sequences, ranging in age from 30 Ma (Initial trap basalts) to Recent, were emplaced and subsequently faulted during rifting processes. Mechanisms of rifting in Afar are still debated, but Northern Afar is generally regarded as the future axis of continental break up because of its highly thinned lithosphere.

Sedimentary infill in Northern Afar is dominated by poorly dated (Mio-Pliocene) clastic red beds (RBS), overlain by thick evaporite sequences in the Dallol Basin to the north. The RBS under study are exposed in the Berhale area, along the western margin of the Danakil depression. The ca. 300 m-thick exposed sedimentary succession encloses two basaltic lava flow sequences, and their feeder sill network that both yield ca. 6 Ma ages (Ar/Ar method). The RBS studied area recorded moderate extension, principally achieved by a few normal faults that locally acted as pathways for hydrothermal fluids during intra-RBS magmatism.

The RBS succession is divided into four main sedimentary units. The basal Unit (A), that directly overlies crystalline basement terrains, is composed of pelitic red sediments, interbedded with thin conglomeratic beds deposited by debris flow processes. Unit A typically represent alluvial fan deposits. Unit B shows fining upwards sequences of cross-bedded conglomerates and sandstones, intercalated with clay beds, typical of fluvial deposits. The upper part of Unit B encloses a widespread sequence of siltstones, interbedded with rippled-laminated and fine-grained sandstones interpreted as fluvial terminal splays in a playa lake. Unit C contains fluvial conglomerates passing laterally to well-sorted shallow marine sandstones. Unit D displays thick sequences of fluvial boulder-sized conglomerates. The overall RBS sedimentary succession exposed in the study area is assumed to result from four successive phases of drainage evolution during a progressive catchment enlargement, concomitantly to an increasing erosion through time of the uplifted basement footwall block in the Ethiopian plateau.

The ca. 6 Ma-old RBS basin is assumed to post-date a major episode of extension to which are assigned (1) an inferred deeply-buried sedimentary depocenter, (2) the main fault system bounding to the west the Danakil Depression, and [3] the pronounced lithospheric thinning, geophysically imaged beneath the Depression.

INFLUENCE OF LONG TERM EXPOSURE SURFACES ON THE ORIGIN, PERSERVATION AND DISTRIBUTION OF MICROPOROSITY IN SHALLOW-WATER CARBONATES : THE BARREMIAN-APTIAN PLATFORM FROM SE FRANCE

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The microporous Urgonian limestones of Late Barremian / Early Aptian from Provence (SE, France) have been studied to estimate the influence of the Durancian exposure unconformity and the related diagenetic processes in the genesis, the preservation and the distribution of microporosity in carbonates sequences. A high-resolution tracking of the vertical and lateral evolution of porosity and diagenetic attributes has been performed for microporous carbonate bodies at kilometer-scale. The development of microporosity results from a complex interaction between early marine diagenesis, stratigraphic stacking pattern, early structuration of the reservoir and fluid circulations during longterm exposure events. Petrographical (sediment texture, facies) and diagenetical analyses (cement stratigraphy, porosity, permeability and isotope geochemistry) of more than 100 limestone samples revealed that early meteoric cementation during repeated subaerial exposures in autocyclic, peritidal parasequences led to the entire occlusion of intergranular and intragranular pore space (=tight limestones). In contrast, shallow-water carbonate sediments that have not been early exposed during repeated emersion have kept a significant fraction of the intergranular macroporosity during burial. Such porous carbonates have been subject to micrite neomorphism during meteoric shallow burial diagenesis associated with the regional Durancian Uplift event (Albian-Lower Cenomanian) and the structuration / compartimentalization of the area. This process resulted in significant intragranular microporosity development. Cementation of the intergranular space occurred during later burial diagenesis and/ or telogenesis (late Cretaceous and Tertiary). Finally, circulation of meteoric fluids during exhumation led to intercrystalline microporosity enhancement and moldic porosity development. The results of this outcrop study could be used as analogs of Middle East microporous reservoirs linked to meteoric events.

CENOZOIC EVOLUTION OF THE GLORIEUSES ISOLATED CARBONATE PLATFORM (EPARSES ISLANDS, SW INDIAN OCEAN) RECONSTRUCTED BY NUMERICAL STRATIGRAPHIC MODELING PRELIMINARY RESULTS

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This study focuses on describing and reconstructing the long-term stratigraphic evolution of the Glorieuses archipelago (SW Indian Ocean) since the onset of Paleocene. It aims at better understanding timing and processes of the shallow-water carbonate platform growth (including the export of sediments towards the surrounding deep basin) and demise, in particular in relation to global sea-level variations.

Previous studies combining geophysical and geological data already pointed out morphological features that give precious guides to understand the Glorieuses platform evolution. The flanks of its platform and the nearby areas are characterized by several flat-topped morphologies and associated slope breaks respectively ranging around 1100 m, 750 m and 200 m water depths. All these flat-topped terraces are located on a rough submarine ridge, the top of which occurs at 1000 m water depth, northwest of the Glorieuses Platform. A coralgal limestones sampled on top of the 750 m depth terrace has been dated to 61.52 ± 1.80 Ma, which suggests that this drowned terrace developed in a shallow-water depositional environment during the Paleocene (at the latest). Overall, the distinct terrace levels observed along the flanks of the Glorieuses carbonate platform are interpreted as resulting from successive development and backstepping episodes, before the initiation of modern shallow-water carbonate systems.

This work is mainly based on seismic interpretations of both Sparker and Multi-channel seismic datasets respectively located on the platform and in the basin (although that its penetration is weak, sparker dataset provides us guides for estimating recent carbonate production rate). Three main regional sequences were identified in the basin adjacent to the platform by their distinct seismic facies, which include (calci)turbidites, Mass Transport Complex, contourites drifts, and erosive channel fills. A 3D Geological model was thus built (thickness and depth maps of all these sub-units and their boundaries, with their relative chronology), providing both (i) the stratal architecture model that we have to numerically reproduce, and (ii) some qualitative and quantitative information to constrain the requested input parameters for numerical runs (initial basement morphology, mean production rate on the platform, sediments fluxes deposited in the surrounding area (slope vs basin floor), sources of sediments, mean subsidence rate, etc...).

These parameters and others (such as volcanic pulses, detrital inputs, hydrodynamical conditions....) should also be polished, and/or refined in function of the accuracy and resolution attempted. Results of the on-going numerical simulations using DIONISOS (Granjeon & Joseph, 1999) should bring us (i) some chronostratigraphic constrains within the deep basin stratal architecture, and (ii) quantifications of sea-level cycles impacts on the development and the demise stages of the platform. These results will finally allow to determine the main driving factors and their quantitative impacts on the long-term evolution of an isolated carbonate platform.

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A RECORD OF DEEP-SEA SEDIMENTATION CONTROLLED BY EUSTASY, CLIMATE AND TECTONICS: CASE STUDY FROM THE CAMPANIAN–MAASTRICHTIAN OF THE POLISH CARPATHIANS

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The Campanian–Maastrichtian was a period of global climate change from warm to cool greenhouse conditions. The change proceeded through various short-term climatic events and was accompanied by sea-level fluctuations of various scales. In the Carpathians, the Campanian–Maastrichtian deposits are locally highly enriched in calcareous material. This is particularly distinct of the upper Campanian–lower Maastrichtian of the outer marginal zone of the Skole nappe which is built of sediments deposited in northern marginal zone of that part of Tethys, i.e. in the Skole Basin. The Late Campanian–Early Maastrichtian deposits there are represented by a ca. 100 m thick succession called the Kropiwnik Fucoid Marl (KFM). It consists of deep-marine, thinly-bedded, soft to hard turbiditic marlstones interbedded in various proportions with mainly thinly-bedded turbiditic sandstones, locally conglomerates, and with muddy to clayey turbiditic to hemipelagic shales. The deposits show cyclic vertical fluctuations between bed packages that consist mainly of siliciclastic sandstones and mudstones and contain little or no marlstones, and packages that are dominated by marlstones. More than 20 such cyclothems are recognizable. The origin of this cyclicity has long been disputed and attributed variously to either tectonic activity or short-term eustatic sea-level changes.

Lithofacies and calcareous nannofossils anlysed recently in the KFM succession between the villages of Huwniki and Rybotycze indicate sea-level changes and associated changes in oceanographic conditions as the main controls on sedimentation, driven by global climate, with a subordinate role of local tectonics. Sea-level falls and lowstands resulted in an increased redeposition of siliciclastic sediment and led to oligotrophisation of surface water by antiestuarine type of circulation as reflected in the low frequency and high taxonomic diversity of nannofossil assemblages. The highstands, in turn, appear to have enhanced primary carbonate production in a widened shelf zone with estuarine type of circulation and upwelling, and increased redeposition of carbonate sediment to the deep-water basin.

Palaeocurrent directions recorded in sandstones indicate sediment supply from extrabasinal sources located on the European Platform and from newly uplifted intrabasinal areas. Deposits such as extraclastic cobble conglomerate, a slump unit and numerous thin layers of intraclastic mud-chip conglomerate, found in the Huwniki section but absent in an adjacent section farther away from the Skole nappe margin, suggest sediment supply from an intrabasinal source that might have been a blind-thrust anticline formed by the ongoing Laramian tectonic contraction. The KFM succession thus exemplifies a combined effect of global climatic and oceanographic changes that occurred in the Campanian–Maastrichtian, with an additional impact of local tectonics.

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MULTI-PROXY PALEOENVIRONMENTAL RECONSTRUCTION OF SALINE LAKE CARBONATES: PALEOCLIMATIC AND PALEOGEOGRAPHIC IMPLICATIONS: THE UPPER EOCENE OF THE ISSIRAC BASIN (SE FRANCE)

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In spite of significant discoveries (e.g. in the Campos Basin-Brazil, in Cabinda-Angola, in the Uinta Basin-USA) that demonstrated the prolific oil reservoirs of the syn-rift lacustrine carbonates, little is known about the processes driving the sedimentary architecture and the factors controlling such systems.

The Issirac basin (SE France) is a small-sized (5x15 km), N110 syncline basin formed during the Eocene NNE-SSW Pyrenean compression and the subsequent West European Cenozoic Rifting. This basin is filled by a 200 m thick carbonate succession, deposited in a shallow lacustrine environment (0-10 m depth). A detailed multi-proxy analysis was conducted on multiple outcrops; it includes sedimentological data (petrographic analysis, facies description, ...), paleontological contents (gastropods, ostracods, charophytes, foraminifera...) and geochemical signatures ($\delta^{18}O$ and $\delta^{13}C$).

This allows us to determine depositional models and the paleoenvironmental evolution of the basin. Sedimentary facies are typical of palustrine to shallow lacustrine paleo-environments, organized in a low-energy, ramp margin-type lake. Despite the classical relationship between sedimentation and external controlling parameters (e.g. climate, tectonics impacting lake morphometry...), it appears that in such shallow lakes, sedimentary facies distribution and architectures may be drastically affected by internal parameters relative to lake ecology. Three main facies associations are interpreted in terms of trophic regimes: 1) the macrophyte-related micritic facies association (charophyte-bearing wackestones, chalky mudstones) corresponding to oligotrophic regime, 2) the granular oncoidal-peloidal facies association (oncoid/ooid-rich porous grainstones) developed under mesotrophic regime and 3) the stromatolite facies association (wackestones with planar mats, grazed by gastropods; low-relief stromatolites; evaporite-rich facies) during eutrophic regime or higher salinities.

Thus, this work proposes new assumptions on sedimentary facies control of a shallow microbial carbonate lacustrine system submitted to fluctuating salinity and trophic regime. The recognition and the study of the interplays between sedimentation, large-scale paleoenvironmental constraints, but also internal parameters (lake ecology, faunal/floral competition...) are fundamental in order to provide an accurate view of lake sedimentation in the past.

INTEGRATED CHARACTERIZATION OF A MIXED (CARBONATE-SILICICLASTIC AND EVAPORITIC) LACUSTRINE SYSTEM IN RIFT BASIN SETTING: THE ALÈS-ISSIRAC-ST CHAPTES BASINS, LATE EOCENE – EARLY OLIGOCENE, SE FRANCE

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The lateral and vertical facies variability inherent to sedimentary systems is a major issue for stratigraphic interpretation and thus for petroleum system evaluation (organic matter accumulation, extent and nature of seals and reservoirs). This is especially true in lacustrine plays, where sedimentation often reflects the complex interplay of different sediment sources (carbonate, evaporitic and siliciclastic components) and sedimentary processes (microbially-induced precipitation, physicochemical reactions, hydrodynamism...). In this regard, Tertiary lacustrine mixed systems (Green river – USA, Sunda Lakes – Indonesia and Malay Peninsula, Sudan rifts...) are challenging basins for O&G exploration. The late Eocene and Oligocene are also periods of prolific lacustrine mixed sedimentation in rift basins from south-western Europe, and could serve as potential analogs.

The studied lacustrine system comprises three connected basins located in the South of France: the Alès basin developed along the bordering Alès listric fault, and the adjacent St-Chaptes and Issirac basins. Good-quality outcrops combined with subsurface data offer the opportunity to study this sedimentary system from the proximal lake margin to the central deep part of the lake.

The integration of detailed outcrop study, petrographic analysis, paleoecological interpretations of the biological assemblages along with carbon and oxygen stable isotope geochemistry allowed to assess the paleoenvironmental evolution of the lake margin (palaeosalinity) and to reconstruct the depositional architecture. A similar approach has been performed in the lacustrine basin depocenter, from subsurface data (cores and well-logs) in order to correlate marginal and profundal lake deposits. In parallel, the chronostratigraphic framework was constrained by combining charophyte biostratigraphy, magnetostratigraphy and seismic interpretation.

The stratigraphic architecture is interpreted in terms of changes of 1) lake level, 2) trophic regimes, 3) salinity and 4) terrigenous supplies. Extensive development of marginal lacustrine/palustrine carbonate reservoirs and playa evaporites seems to occur during lake level highstands and to correlate with profundal lacustrine source rocks. Thick developments of evaporites in the lake depocenter may occur during lake level drops and correlates with major subaerial exposures in the lake margin.

SHELF RIDGES: STRATIGRAPHIC CHARACTERIZATION AND PROCESS DOMINATION. AN EXAMPLE FROM THE CAMPANIAN ALMOND FORMATION, WYOMING

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Shelf ridges are sedimentary bodies very common in modern continental shelves. Formed during transgression, shelf ridges obtain their sediment from the erosion and rework of previous low-stand deposits by storms or tidal currents. Despite being common in modern environments, they have been largely ignored in ancient studies, and only recently some examples have been identified in the geological record. This lack of ancient examples is caused by a lack of defined facies models. Previously identified ancient shelf ridges, modern examples and a field case study from the Western Interior Seaway are used to generate a facies model for shelf ridges and to propose several recognition criteria for this kind of sedimentary deposit.

As a field example we present two of the uppermost sandstone bodies of the Campanian Almond Formation in the Hanna Basin of Wyoming. These two sandstone bodies, previously identified as shorefaces, have been characterized through sedimentological descriptions, photomosaic interpretation and LiDAR imaging. The sedimentological characteristics, surface geometries and body architecture are inconsistent with their interpretation as shorefaces and elicits their reinterpretation as shelf ridges.

We propose six main characteristics that serve as recognition criteria of ancient sandstone shelf ridges: 1) they are encased in thick marine mud intervals above and below, 2) they have a basal unconformity, a transgressive surface that eroded into marine muds or into the remnant of a previous shoreline, 3) the upper boundary is non-erosional and transitions into marine muds, 4) they are formed by very clean and well-sorted sandstone, usually cross-stratified where tidal currents were involved 5) they contain fully marine ichnofauna, and 6) they present compound architectures with large accretion surfaces and lesser order cross-strata inside. Additionally, we propose a facies and evolutionary model for these deposits that honors the process regime (tidal vs storm domination), and highlights the complex internal architecture and heterogeneities present in shelf ridges. These facies and evolutionary models have great applicability in reservoir modelling to predict internal flow barriers and reservoir volume and distribution can help to reconstruct not only shelf ridges evolution during a transgression, but they can also help to better characterize process dominance and process changes during a relative sea level rise (storm domination vs tidal domination, linked with tidal resonance in the basin).

HYDRAULIC PARAMETERS, SEDIMENT PARTITIONING AND PROVENANCE OF A FLUVIAL SYSTEM IN RESPONSE TO SPATIALLY VARIABLE SUBSIDENCE: THE CANYON CREEK MEMBER OF THE ERICSON FORMATION, WYOMING, USA

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The Canyon Creek Member (CCM) of the Ericson Formation in south-western Wyoming was deposited by a fluvial system that drained the highlands of the Sevier Orogenic belt and traveled eastwards towards the Western Interior Seaway of North America during the Campanian age. This ancient fluvial system has been studied using a well-log and outcrop dataset covering an area of approximately 45,000 km^2.

This work shows how incipient Laramide structural highs modified the behavior, style and architecture of the fluvial system, affecting its thickness, facies characteristics and net-to-gross both down-dip and along strike across the basin. These uplifts rather than real topographic features were only areas of reduced subsidence at the time of deposition of the CCM. Surface expression at that time must have been minimum, only minute changes in slope and accommodation.

Outcrops around these Laramide structures, in particular both flanks of the Rock Springs Uplift, the western side of the Rawlins uplift and the north flank of the Uinta Mountains, have been sampled to study the petrography, grain size, roundness and sorting of the CCM, which along with the cross-bed thickness and bar thickness allowed calculation of the hydraulic parameters of the rivers that deposited the CCM. This study reveals how the fluvial system evolved and responded to the very small changes in subsidence and slope. Furthermore, the petrography will shed light on the provenance of these sandstones and on the relative importance of Sevier sources versus Laramide sources.

SEDIMENT PROVENANCE DURING TWO GONDWANA GLACIATIONS IN ETHIOPIA: INSIGHTS FROM PETROGRAPHY, GEOCHEMISTRY, AND HEAVY MINERALS

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With the amalgamation of Gondwana in the Neoproterozoic the East African Orogen came into existence. Erosion products of this large mountain range are mature sandstones that blanketed large parts of Gondwana during the Palaeozoic. In Ethiopia, Palaeozoic sedimentary successions can be assigned to the two major Gondwana glaciations during Late Ordovician and Carboniferous–Permian times. The distribution of ice sheets and continent-wide glacier dynamics during these glacial periods are still under discussion. Apart from the Arabian-Nubian Shield as a probable local source region, far-distance transport from central Gondwana (e.g., East Africa) needs to be considered. Ethiopia is a key region between potential far-distant sediment sources and the northern margin of Gondwana.

We compare sediments of both glaciations regarding their petrography, geochemistry and heavy minerals to assess differences in provenance, weathering and transport conditions and the implications for the respective glacial system.

For the Late Ordovician sediments, petrography and geochemistry and the enrichment of ultra-stable heavy minerals (mainly zircon, rutile, and tourmaline) show high maturity pointing to intense weathering and reworking prior to deposition – yet no evidence for sediment recycling was found. In contrast, the Carboniferous–Permian sediments are less mature and show indications for a higher input of juvenile material, most probably from proximal sources. The presence of garnet points to little influence of acidic weathering. No evidence for recycling of the Ordovician sediments were found. Zircon ages of both formations are mainly Pan-African with minor Paleoproterozoic ages. Ordovician samples contain an additional group of Tonian–Stenian detrital zircons.

Comparison with stratigraphically corresponding formations in Saudi Arabia shows similar geochemical patterns in the Late Ordovician samples, whereas in the Carboniferous–Permian major differences can be identified. This supports previous assumptions of a large, uniform sediment system during the Early Palaeozoic, in which a combination of long transport paths and exceptionally strong weathering prior to deposition produced mature sandstones. During the Late Palaeozoic the glacial systems on Gondwana seem to have been more localised and glacial abrasion liberated fresh basement material.

TECTONO-SEDIMENTARY EVOLUTION OF THE MIOCENE-PLIOCENE SERIES OF IBIZA: NEW ONSHORE EVIDENCE OF THE MESSINIAN SALINITY CRISIS

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Miocene-Pliocene units outcropping on the NE part of the Ibiza Island were studied in order to establish their sedimentological and stratigraphic characteristics and to propose a tectono-sedimentary evolution. They are for the first time interpreted in regard to the MSC crisis.

In the Ibiza Island the Upper Miocene is composed, first, by fossil-rich limestones (benthic foraminifera, corals, rhodolits...) accumulated in shallow marine environments. This sedimentary Unit (Unit 1) presents faciologic similarities with the Heterozoan unit previously described in Sorbas and therefore could be Late Tortonian to Lower Messinian in age. It rests everywhere on the Mesozoic series. U1 is overlaid by a detrital unit (Unit 2) setting up by gravitational and fluvial processes in nearshore environment. The edification of the coastal alluvial fans is controlled by extensional faults. The activity of these faults starts during U1 deposition and seems to control the Upper Miocene location in the Ibiza Island. The Unit 2 is onlapped by oolite, microbialite (thrombolite, stromatolite), gastropods – rich limestones (Unit 3), that can be interpreted as the TCC (Terminal Carbonate Complex) found elsewhere onland Spain. These three units were deposited in shallow water or nearshore environment and record a transgressive general trend.

The major relative sea level fall is recorded after the deposit of the TCC and is marked by the formation of paleosols and wind dunes. The resulting continentalization was contemporaneous with gravitational instabilities affecting TCC (bending) and gravity flows like mud flow and debris flow incising into the TCC. At the same time, the Miocene and Mesozoic series were locally strongly eroded. These last events are related to the pick of the Messinian Salinity Crisis.The important erosion and karstification surface locally draws valleys building the “calas” that reflects the Present-day landscape. This surface is filled with unit called U4 formed by shallow marine calcarenites with gastropods, benthic foraminifera, red algae that could be Zanclean in age, and covered by eolian bioclastic sands dated from Pleistocene. This surface corresponds to the Messinian Erosion Surface (MES) that has been followed from deep basins (Algerian and Liguro-Provençal basins) to intermediate depth basins (Valencia basin and Balearic Promontory subbasins) up to the Ibiza offshore slope domains.

The studied series allow a stratigraphic calibration of the Messinian Erosion Surface and show numerous destabilization (bending, gravitational processes) contemporaneous with Messinian crisis but without link with salt deposits or remobilization.

GEOMORPHOLOGY AND SEDIMENTARY HISTORY RESTORATION OF THE TRANSITIONAL BRAIDED-MEANDERING RIVER RESERVOIR: TAKING KONGDIAN OIL FIELD IN SOUTH BOHAI BAY BASIN, CHINA AS AN EXAMPLE

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Existing sedimentary models are not well suited for reservoir architecture analysis at present, especially for complex reservoirs resulting from river transition, which lacks sedimentary history for guidance. A detailed study of Kongdian oil field located in the south of Huanghua depression, Bohai bay basin is carried out first. Seismic geomorphology and sedimentology based on high resolution 3D seismic data provide an effective tool to study the subsurface depositional geomorphology and processes. Through the restoration of paleogeomorphology, the paleogeomorphological features were determined. The provenance direction of the study area was determined, and the influence of paleogeomorphology on river type evolution was analyzed. The results show that topographic slope and sediment supply mainly control such an evolution. In the lateral expansion direction of the channels, the fluvial deposit is mainly controlled by topographic slope; while along the provenance direction, the sediment supply becomes a major controlling factor. The major distribution direction of sandbody is from Southwest to Northeast. With comprehensive analysis of the outcrop, core data, well logs and petrology description, this paper summarizes the sedimentary and evolutional characteristics of braided river, meandering river and transitional river. Finally, a vertical evolution history of braided river deposit to meander river deposit and meander river deposit to braided river deposit is established.

DISCUSSION ON THE NON-PERMEABLE BARRIERS AND INTERLAYERS IN A BRAIDED RIVER RESERVOIR: A CASE STUDY OF KONGDIAN OIL FIELD IN SOUTHERN BOHAI BAY BASIN, CHINA

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With the increase of moisture content in the reservoirs, productions rates are strongly dependent on sand body thickness, connectivity and heterogeneity, Kongdian oilfield, Southern Bohai Bay Basin of China. This is because the deposits underneath have complicated internal architectures, which make it challenging to delineate. To solve the problem in an alternative approach, this study is focused on the non-permeable part within the reservoir and to present a geologic model that captures the geometries of the sands-mud heterolithic stratification. Most of the time, they act as barriers and are potentially more significant for flow behavior and reservoir performance than the permeable part. Therefore, when the distribution and geometries of non-permeable barriers are ascertained, the aim to fully characterize the reservoir becomes much easier and feasible. With a detailed study includes comprehensive analysis of well logs, core data and petrology description of the Guantao Formation in Kongdian oilfield carried out, two categories of deposits are classified: the sand-rich units (e.g. side bars, mid-channel bars, sandy channel fills) and the mud-rich units (e.g. abandoned channel mud plug, channel lag mud, muddy bar drape). In addition, 3 probable geneses about the non-permeable barriers or interlayers are summarized. In process of the study, techniques such as modern depositional pattern analogy along with empirical formula fitting have been used, to establish the quantitative database of the mud-rich units. We have further revealed key variables such as abandoned channel width, muddy bar drape dimension. The 3D seismic data and the aid of horizontal wells proved useful in interpreting the top and base of the sand groups and the boundaries of individual channel trends. As a result, the abandoned channels identified are approximately 220 m wide, mud-drapes within the bars are 110-500 m wide and 350-1100 m long. These prediction results are useful in constraining conceptual depositional model and geological model. Dipmeter data were used to identify the dominant accretion dip azimuth and angle at each well location within each channel trend. These data were then used as a guide to construct curvilinear dip surfaces and inclined grids, which served as the stratigraphic framework for conditioning the reservoir portion of the model. The final model provides guidance for exploration and development.

LATERAL ACCRETION MODELING OF FLUVIAL SYSTEMS IN GUANTAO FORMATION: KONGDIAN OILFIELD IN SOUTH BOHAI BAY BASIN, CHINA

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Large-scale point bars and other laterally accreting channel systems in the GuanTao Formation represent the most important reservoirs in the KongDian oilfield of Bohai bay Basin, China. With the increase of moisture content in the reservoirs, productions rates are strongly dependent on sand body thickness, connectivity and heterogeneity. As a result, an industry goal has long been the construction of geologic models and reservoir simulations that realistically represent the reservoir architecture and flow units in these complex systems. However, until recently, computing power and necessitated the broad use of layered models that exhibit simple layering geometries. The purpose of this study is to present a geologic model that captures the geometries of the sands-mud heterolithic stratification, inclined sands and their associated basal channel sands. The model integrates GuanTao Formation outcrop observations with core, log and 3D seismic data from KongDian Oilfield in South Bohai bay Basin of China. Four architecture hierarchies including composite meandering belt, single meandering belt, single point bar and lateral accretion bodies were identified and analyzed. 3D reservoir architecture model and petrophysical property models were developed, and the numerical reservoir simulation based on 3D practical reservoir architecture model was finished. According to reservoir modeling and numerical simulation, the remaining oil distribution patterns of the meandering river reservoir controlled by different hierarchy architecture elements and development factors were summarized, which are composite meandering belt including lateral facies change and interlayer interference, single meandering belt including interformational rhythm and abandoned channel barrier, lateral accretion bodies including lateral accretion shale bedding barrier. The results show that the lateral accretion bedding thickness in single well of KongDian Oilfield is about 0.3-1.8 m, extending to 3/5 thickness of channel sandbody downward and inclining to abandoned channel, and dip angle is 5°-10°. The 3D seismic data proved useful in interpreting the top and base of the sand groups and the boundaries of individual channel trends. However, the pattern of lateral accretion could not be consistently determined. As a result, dipmeter data were used to identify the dominant lateral accretion dip azimuth and angle at each well location within each channel trend. These data were then used as a guide to construct curvilinear dip surfaces and inclined grids, which served as the stratigraphic framework for conditioning the reservoir portion of the model. The model also makes possible better planning of horizontal well pair trajectories.

PALEOCENE-EOCENE THERMAL MAXIMUM (PETM) IN TETHYAN HIMALAYA (SOUTHERN TIBET): IMPLICATIONS FROM SHALLOW WATER CARBONATE

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The Paleocene-Eocene Thermal Maximum (PETM) was a geologically rapid and transient warming event that occurred ca. 56 million years ago (Ma). It was associated with a pronounced negative carbon isotope excursion (CIE) and with profound changes in the atmosphere, hydrosphere and biosphere. The well preserved Paleogene carbonate successions in the Tibetan Tethyan Himalaya offered an excellent opportunity to identify the Paleocene-Eocene thermal maximum and its tectonic and climatic implications.

The detailed stratigraphic record of the Paleocene–Eocene Thermal Maximum (PETM) is preserved in the Gamba area of the Tethyan Himalaya (Southern Tibet), a carbonate-platform succession originally deposited along the southern margin of the eastern Tethys Ocean. The Paleocene-Eocene boundary interval is marked by a negative carbon isotope excursion at the boundary between members 3 and 4 of the Zongpu Formation. The succession is erosionally truncated at this surface, which is overlain by an intraformational carbonate conglomerate, and only the upper part of the PETM interval is preserved.

Foraminiferal assemblages of Shallow Benthic Zone 4 are present below the conglomerate bed, but are replaced by assemblages of Shallow Benthic Zone 6 above the conglomerate. Depositional facies also change across this surface; below the disconformity, floatstones and packstones containing nummulitid forams record progressive transgression in an open-marine environment, whereas restricted or lagoonal inner-ramp deposits containing *Alveolina* and *Orbitolites* are typical above the disconformity. The prominent negative excursion observed in the $\delta^{13}C$ of whole-rock carbonate (-1.0‰ at Zongpu,- 2.4‰ at Zengbudong) and organic matter (-24.7‰, at Zengbudong) is correlated to the characteristic PETM carbon isotope excursion.

The erosional unconformity can be constrained to the lower PETM interval (between 56 and 55.5 Ma), and is identifiable throughout the Tethyan Himalaya. Two scenarios may be envisaged for the widespread disconformity: 1) tectonic uplift associated with the southward migration of an orogenic wave, originated 3±1 Ma earlier in the Middlemiddle Paleocene at the first site of India-Asia continent-continent collision; 2) pre-PETM sea-level fall which resulted in the excavation of incised valleys, filled during the subsequent sea-level rise when the conglomerate bed was deposited, which remains to be assessed.

A CASE STUDY ABOUT FLUVIAL SYSTEM: ARCHITECTURAL ANALYSIS OF THE SULIGE GAS FIELD, ORDOS BASIN

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Ordos Basin, the second major sedimentary basin in China, is located in the mid-western China. The target area we do research is Sulige gas field in Ordos Basin. Aiming at Shihezi Fm (Formation) and Shanxi Fm of the Permian, we developed architectural analysis in the guidance of Seismic Sedimentology. Depending on observed outcrop data, core data, logging, 3D seismic, we summed up the rock-electricity features of different architecture units and established a fine architecture mode. Macroforms can be identified in the meandering river of Shihezi Fm and Shanxi Fm, such as point bars and inclined bars. However, in the braided fluvial river of Shihezi Fm, mid-channel bars can be distinguished. We divided four architecture elements, including channels (CH), gravelly bars and bedforms (GB), sandy bedforms (SB), foreset macroforms (FM). Five diverse kinds of architecture bounding surfaces, containing First-order surfaces, Second-order surfaces, Third-order surfaces, Fourth-order surfaces, Fifth-order surfaces, are well developed in braided river. Three different kinds of architecture bounding surfaces in meandering river are as follows: Third-order surfaces, Fourth-order surfaces, Fifth-order surfaces. According to architectural analysis, braided overlap channels sand-conglomerate body in the Sulige gas field can be distinguished four different spatial superimposed pattern. The connectivity of sand body is poor. Most of the sand is isolated, and part of them is unilateral. The single stage river was tracked and compared using the methods of Seismic Sedimentology. On account of modern sedimentary and architecture theories, the results were confirmed by interference well testing which can confirm that the time of stage redefinition and the predicted results were reliable. Based on above the evolution and sedimentary history was researched according to the order of sedimentary development.

METHODOLOGY INTEGRATION: PREDICTION OF SOURCE ROCKS

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The prediction of source rocks is very important to the basin at the initial stage of exploration, among which the description of the source rocks' spatial distribution and the evaluation of the source rocks' quality are the most significant. For most of the oil and gas fields on the land, the prediction and evaluation of source rocks rely on geochemistry analysis. However, for offshore exploration area, the prediction of source rocks is limited to the well data. With the development of 3D seismic exploration technology, combining well data and seismic data is using to forecast source rocks. Normally, the prediction method is divided into three steps. First, according to the general characteristics of source rocks'low frequency-high amplitude' in seismic section, we can determine the location of source rocks. Then, the distribution of source rocks will be calculated by percentage of shale. Last, we adopt geophysical inversion to obtain the distribution characteristics of Total Organic Carbon (TOC). Nevertheless, there are certain unreasonable details. For instance, it is imprecise to confirm the layer where source rocks developed only according to seismic profile as observation. What's more, when most researchers calculate the percentage of shale, they don't consider the influence of sedimentary environment. Although percentage of shale varies from different depositional environment in the same exploration area. Apparently, predicting in this way reduces the accuracy. Similarly, sedimentary face and other factors are not considered in geophysical inversion, the inversion result is relatively rough. In order to solve the above problems, we improved the method of predicting source rocks by using Fourier Transform and adding sedimentary face to control. For the first step, through Fourier Transform to the time domain seismic data to identify the location of the source rocks in the frequency domain. In this way, the identification information is quantitative and the recognition accuracy is greatly promoted. As to the second step, we count the percentage of shale with different sedimentary face. Using the different percentage of shale to achieve the high-precision thickness value of source rocks. With regard to geostatistical inversion of the third step, sedimentary face controlling factor play an essential role. In the prediction of source rock in the East China Sea Basin, the prediction method combining sedimentary face with geophysics is effective, and the prediction accuracy is greatly improved.

RESERVOIR CHARACTERISTICS AND CONTROL FACTORS OF TIGHT LACUSTRINE CARBONATE RESERVOIRS IN SHULU SAG OF BOHAI BAY, CHINA

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The potential of unconventional oil and gas exploration is large and has broad prospects. Lacustrine carbonate deposits are widely reported in the Tertiary lake basins of Bohai Bay area in China, and they are generally considered as potential oil exploration targets in these basins. Shulu Sag located in south-western corner of Jizhong Depression, (central Hebei province) filled by Tertiary lacustrine source-controlled carbonates with abundant accumulation of organic matter, and they are very important oil producing basins in China. The calcilutites in the basin act as both source and oil reservoir. However, there is little research on the formation law of tight lacustrine carbonate reservoirs and the knowledge and effective evaluation methods on tight lacustrine carbonate reservoirs are insufficient. On the basis of the core, thin section and SEM analysis, combined with X-ray diffraction and geochemistry test, this article focuses on reservoir space characteristics and control factors of tight lacustrine carbonate of lower part of Es3, in Shulu Sag. Eight lithofacies were identified based on mineral composition and sedimentary texture and structures: 1) Matrix-supported carbonate rudstones, 2) Clast-supported carbonate rudstones, 3) Calcarenites, 4) Calcisiltite-calcilutites, 5) Massive calcareous mudstone, 6) Laminated calcareous mudstone, 7) Laminated argillaceous calcilutites, 8) Massive argillaceous calcilutites. Four types of pores and three kinds of fractures are present in the tight carbonate reservoirs in study area. The pores include organopores, intercrystalline pores, intergranular dissolved pore, intragranular dissolved pore. The fractures include abnormal pressure fractures, interlayer microfractures and and steeply dipping fractures. The reservoir space feature is mainly controlled by lithology and mineral composition, the occurrence of organic matter, tectonism, diagenesis and abnormal pressure. The variability in lithologies and mineralogy are result in a variety of reservoir space types and relative content. A lot of algae has been found in the study area under SEM. The algae are present in both laminated calcilutites and Matrix of Carbonate rudstones, which shows a common phenomenon and suggest the biogenic original. An abundance of pores in organic matter is directly related to thermal maturity. The density of structural fractures constructs a positive correlation with calcite content. The laminar structures have large effects on interlayer microfractures. Tectonism plays an important role in the formation of tectonic fractures. The fibrous carbonates filled in pores are believed to reflect precipitation in overpressured systems where frature-walls are held apart by fluid pressure. Bitumens are present within fibrous mineral carbonates, which indicates the migration of hydrocarbon fluids.

CHANGE FROM TIDE-INFLUENCED DELTAS IN A REGRESSION-DOMINATED SET OF SEQUENCES TO TIDE-DOMINATED ESTUARIES IN A TRANSGRESSION-DOMINATED SEQUENCE SET, EAST CHINA SEA SHELF BASIN

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The East China Sea Shelf Basin (ECSSB) was a back-arc basin located at the active continental margin of the western Philippine Sea Plate. We explore facies and architectural changes from tide-influenced deltas to tide-dominated estuaries in transgressive-regressive cycles in this basin, as well as their controlling factors. Cores, wireline well-logs, and seismic data allow the sedimentary architectures and models of the depositional systems to be reconstructed. In the Xihu Depression of the ECSSB, the stratigraphic sequences of the Eocene Pinghu Formation are interpreted as dominated by repeated phases of deltaic progradation, but with intervening transgressive phases only thinly developed as bioturbated, open-marine shelf deposits. The sequences of the overlying Oligocene Huagang Formation, in contrast, are interpreted as stacked, tide-dominated estuary units, alternating with only poorly preserved regressive half cycles because of repeated, strong estuary down-cutting. The intervening unconformity in the succession corresponds to the Yuquan tectonic movements, which triggered a change from extensional to compressional settings in the Xihu Depression. In the Late Eocene, extension of the Xihu Depression led to moderately high rates of subsidence (163 m/Ma) and sedimentation (17.12 cm/ka), and short-term sea level falls led to multiple phases of deltaic progradations. After the Yuquan Movement, Early Oligocene compression brought over all lower rates of subsidence (110 m/Ma) and sedimentation (6.88 cm/ka), as well as sea level rise and stacked estuary development with significant tidal influence in the infill. The interaction of tectonics, sea level change, and sediment supply determined the nature of the depositional systems on the shelf during the entire period, whereas the sedimentary processes were key to reworking and shaping the facies distribution, geomorphology, and architectures in the back-arc basin. This research provides an insight into spatial and temporal characterization of deltaic and estuarine systems, contributing to a better understanding of the mechanisms controlling a change in dominant coastline type, despite continued strong tidal influence.

EFFECT OF SEDIMENTARY ENVIRONMENT ON SHALE LITHOFACIES IN THE LOWER THIRD MEMBER OF THE SHAHEJIE FORMATION, ZHANHUA SAG, EASTERN CHINA

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Shale lithofacies can reflect the sedimentary environment and deposition process; besides, the depositional environment controls the development of shale lithofacies. This study took the lower third member of the Shahejie (Es3l) Formation, Zhanhua Sag, Eastern China as an example and used a series of measures, such as thin section observation, total organic carbon (TOC) analysis, X-ray diffraction analysis, and major and trace element analysis to investigate the effect of sedimentary environment on shale lithofacies. Our research shows that the Es3l sedimentary period was in an environment with warm and wet climate, limited provenance, salty water, and strong reducibility. Moreover, the sedimentary environment of the early stage is with drier climate, more limited provenance, higher salinity, and stronger reducibility than that of the late stage. The Es3l shale is characterized by a high carbonate minerals content, low clay and siliceous minerals contents, a high TOC content and the general development of horizontal beddings. Five types of lithofacies are successively developed in the Es3l shale from bottom to top, namely, organic-fair laminated calcareous shale (OFLCS), organic-rich laminated calcareous shale (ORLCS), organic-rich bedded calcareous shale (ORBCS), organic-rich bedded mixed shale (ORBMS), and organic-rich massive mixed shale (ORMMS). Moist climate and low salinity provide a favorable environment for biological luxuriance; besides, terrestrial input affords adequate nutrients for biological development. Biological blooms can create such large concentrations of organic matter. Reductive water column can protect organic matter from disruptive oxidation. Compared with other shale lithofacies, although the sedimentary period of OFLCS is in an environment with the strongest reducibility, OFLCS has the lowest TOC content (average: 1.59%). It is because the sedimentary period of OFLCS is in an environment with the driest climate, the most limited provenance, and the highest salinity. A dry climate would result in strong evaporation, which is conducive to carbonate minerals precipitation. A clear and enclosed water column without terrestrial input provides a favorable environment for carbonate minerals deposition. Moreover, a favorable environment for carbonate minerals deposition always presents a high salinity. Compared with other shale lithofacies, since the sedimentary period of OFLCS is in an environment with the driest climate, the most limited provenance, and the highest salinity, OFLCS has the highest carbonate minerals content (average: 68.42%). The development of lamellar layers is closely related to the stratification of water column which result in the seasonal deposition of external and internal sediments. The stratification of water column is caused by density difference which is an expression of temperature and salinity differences. The greater the differences are, the more developed the combination of dark and light lamellar layers is. Light lamellar layers are composed of internal carbonate minerals, whereas dark lamellar layers consist of external clay minerals, siliceous minerals and organic matter. Compared with laminated shale, since the sedimentary period of ORMMS is in an environment with small climate and salinity variations, namely, with the poor stratification of water column, ORMMS has a character of massive structure with lack of lamellar layers.

CLASSIFICATION OF SHALE LITHOFACIES IN THE LOWER THIRD MEMBER OF THE SHAHEJIE FORMATION, ZHANHUA SAG, EASTERN CHINA

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Research on shale lithofacies is of great significance for shale oil exploration and development. This study took the lower third member of the Shahejie (Es3l) Formation, Zhanhua Sag, Eastern China as an example and used a series of measures, such as core and thin section observation, total organic carbon (TOC) analysis, X-ray diffraction analysis to investigate the classification of shale lithofacies. Considering that the Es3l shale is rich in organic matter, calcareous minerals, and lamellar layers, a classification of shale lithofacies is proposed on the basis of TOC content, sedimentary structure, and mineral composition. Firstly, taking the TOC contents of 1% and 2% as delimitations, shale can be divided into three types: organic-poor shale (TOC < 1%), organic-fair shale (TOC: 1%-2%), and organic-rich shale (TOC > 2%). Secondly, according to the thickness of horizontal beddings, shale can also be divided into three types: massive shale (> 50 cm), bedded shale (> 2 mm), and laminated shale (< 2 mm). Finally, based on the three-end-member classification, with the three end members being calcareous minerals (calcite, dolomite, and siderite), siliceous minerals (quartz and feldspar), and clay minerals, taking the minerals contents of 50% as delimitations, shale can be classified into four types: calcareous shale (calcareous minerals content more than 50%), siliceous shale (siliceous minerals content more than 50%), argillaceous shale (clay minerals content more than 50%), and mixed shale (three types of minerals contents all less than 50%). Combining the above three kinds of classifications, 36 types of shale lithofacies can be obtained: organic-rich (fair or poor) massive (bedded or laminated) calcareous (siliceous, argillaceous, or mixed) shale. Applying the classification of shale lithofacies to the Es3l Formation in Zhanhua Sag, 5 types of lithofacies are identified, namely, organic-rich massive mixed shale (TOC > 2%, massive structure, three types of minerals contents all less than 50%), organic-rich bedded mixed shale (TOC > 2%, bedded structure, three types of minerals contents all less than 50%), organic-rich bedded calcareous shale (TOC > 2%, bedded structure, calcareous minerals content > 50%), organic-rich laminated calcareous shale (TOC > 2%, laminated structure, calcareous minerals content > 50%), and organic-fair laminated calcareous shale (TOC: 1%-2%, laminated structure, calcareous minerals content > 50%).

MULTISTAGE FLUID-ROCK INTERACTION RECORDS IN CARBONATE RESERVOIRS CONTROLLED BY STRUCTURAL EVOLUTION OF TARIM BASIN, NW CHINA

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The Ordovician Yingshan Formation carbonates, deep buried in Tarim basin, NW China, generally experienced a complicated diagenetic process with multistage structural-fluid regimes. However, a lot of carbonate reservoirs for oil-gas were preserved in the deep/ultra-deep intervals, greater than 6000 m in depth and 160 degrees centigrade in temperature. Based on diagenetic mineralogy and geochemistry, our research shows that six phases calcite cementation were developed in the Yingshan Formation carbonates. The former three-phase cements successively occurred during the penecontemporaneous, hypergene and shallow burial stages, with diagenetic features related to normal seawater. In contrast, the later two-phase cements recorded deep/ultra-deep burial process and are characterized by evidently negative $\delta^{13}C$ indicating organic carbon input. Relatively maximum negative $\delta^{18}O$ and $\delta^{13}C$ are discovered in the fourth cement related to thermalfluid flow. Beside dissolution occurred in the penecontemporaneous and hypergene stages, two-phase burial dissolutions developed in the Yingshan Formation carbonates, in which the second burial dissolution, coupled with hydrocarbon injection, mainly resulted from alterations of dolomites as well as early calcite cements. For the studied area, key epidiagenesis and burial dissolution-cementation of the Yingshan Formation carbonates were influenced by fluid flows, respectively, related to the Middle-Late Ordovician thrust faults in NWW-SEE and WE strikes, the Silurian-Devonian small transfer or transtensional faults in NE strike and the Permian small tension faults in multiple strikes. The late two types of small and easily missed faults can be detected by the new improved cylindrical surface fitting-related method on 3D seismic data. Further it is indicated that the above three stages of faults successively resulted from structural inversion and transition of preexisting main faults and ascending magmatic fluid flows percolating across Ordovician carbonates. Key constructive diagenesis of deep-buried carbonate reservoirs were very sensitive to these faulting and related acidic fluid flow controlled by larger-scale interactions between Tarim basin and neighbor blocks.

DISTRIBUTION OF RARE EARTH ELEMENTS AND YTTRIUM OF SINKHOLE-FILLING DEPOSITS ASSOCIATED WITH AN EROSIONAL UNCONFORMITY ON GRAND CAYMAN

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On the eastern half of Grand Cayman, dolostones of the Cayman Formation (Miocene) have been exposed since the late Pliocene (~3.6 Ma). The exposed upper surface of the Cayman Formation, which is an unconformity surface that is still developing, is characterized by numerous sinkholes. Some of these sinkholes, which are up to 30 m in diameter and 10 m deep, remain open, whereas others are filled with a variety of deposits that include laminar rootcrete, breccias, loose limestone and dolostone lithoclasts, and white, red and orange limestones. The rare earth element (REE) and yttrium (Y) concentrations (ΣREE + Y) of lithoclasts, white limestone matrices, and speleothemic calcite found in sinkholes range from 0.3 to 20.0 ppm (average 8.1 ppm), whereas the ΣREE+Y of the red and orange limeston matrices varies from 21.5 to 77.6 ppm (average 46.1 ppm). The ΣREE+Y of rootcrete, in contrast, varies from 1.2 to 307.1 ppm (average 35.1 ppm).

The REE signatures of the sinkhole-filling deposits are different from those of the bedrock limestones and dolostones. The La/Yb and Sm/Yb ratios for the sinkhole-filling deposits on Grand Cayman, for example, plot along a different trend line than that derived from the Miocene dolostones, the Pliocene limestones and dolostones, and the Pleistocene limestones. Such distinctive REE signatures of the sinkhole-filling deposits emphasises that the sinkhole-filling deposits evolved in a different manner than the Neogene and Pleistocene marine carbonates. Therefore, variations in the REE+Y patterns may offer a means of “fingerprinting” carbonate deposits and determining if they formed in marine or non-marine settings.

PROVENANCE OF SEDIMENTS FROM SUMATRA, INDONESIA

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The island of Sumatra is situated at the south-western margin of the Indonesian archipelago. Sumatra is affected by active continental margin volcanism along the Sunda Trench, west of Sumatra as a result of active northeast subduction of the Indian plate under the Eurasian plate. Exposures of the Palaeozoic metasedimentary basement are mainly limited in extent to the northeast-southwest trending Barisan Mountain chain. The younger Cenozoic rocks are widespread across Sumatra, but can be grouped into structurally subdivided 'fore-arc', 'intramontane', and 'back-arc' basins. However, the formation of the basins pre-dates the current magmatic arc, thus a classical arc-related generation model can not be applied. The Cenozoic formations are well studied due to hydrocarbon enrichment, but little is known about their provenance history. A comprehensive sedimentary provenance study of the Cenozoic formations can aid in the wider understanding of Sumatran petroleum plays, contribute to the palaeographic reconstruction of western SE Asia, and might help to simplify the stratigraphy of Sumatra.

This work represents a multi-proxy provenance study of sedimentary rocks from the main Cenozoic basins of Sumatra, alongside sediment from present-day river systems. U-Pb detrital zircon dating by LAICP-MS, and heavy mineral analysis are combined to refine the provenance history.

U-Pb zircon age-data of 3519 concordant grains (10% discordant cut-off), heavy mineral compositions, and thin section analysis from two fieldwork seasons indicate a mixed provenance model, with a proximal igneous source, and mature basement rocks. An increase of the proximal signature in Lower to MiddleMiocene strata of the Ombilin Basin and the North Sumatra Basin suggests a change of the sourcing region. This is indicated by the occurrence of unstable heavy mineral phases such as apatite and clinopyroxene. It can be interpreted as a pulse in the uplift of a local volcanic arc, such as the present Barisan Mountains. The presence of volcanic quartz in thin section supports this hypothesis. On the contrary, older sedimentary strata are characterised by ultra-stable heavy minerals such as zircon, tourmaline, and rutile; the presence of garnet in both pre-, and post-uplift affected strata indicates a contribution from metamorphic basement rocks, either from local Sumatran basement or the Malay-Peninsula.

Detrital zircon ages as old as Archean are present in all sedimentary formations. Prominent Triassic ages can be correlated with granitoids reported from the Malay-Peninsula. However, these granites occur locally in eastern Sumatra. The Pre-Cambrian zircon age spectra found in the sedimentary strata can be correlated with zircons ages derived from Sumatran basement rocks. Hence, the Sumatran basement can be regarded as a persistent source throughout the Cenozoic. Zircon age spectra from Sumatra lack some diagnostic age groups commonly found in central-and western SE Asia, such as occurring Cretaceous ages, correlated with igneous rocks of SW Borneo.

The analysis of modern river sands suggests that the current sedimentary fluvial systems are mainly sourced from the recent volcanic arc. Zircon age patterns of the modern river sands resemble the populations found in the sedimentary strata, whereas the heavy mineral composition is highly diluted by the recent igneous sources.

HIGH RESOLUTION FACIES ZONATION AND SURVEY DESIGN AT A DEEP-WATER COLD-WATER CORAL MOUND; THE CASE OF PIDDINGTON MOUND, PORCUPINE SEABIGHT, NE ATLANTIC

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Framework-forming cold-water corals (CWC's) such as Lophelia pertusa and Madrepora oculata generate positive topographic features on the seabed called CWC mounds. In the North East Atlantic, CWC mounds have been studied in detail and reveal heterogeneous spatial on-mound organisation of coral patches. Many of these studies are limited by a paucity of remotely-sensed and video imagery at an appropriate resolution and coverage. Furthermore, a standardised approach to monitoring the effects of climate change, anthropogenic impact and natural variability through video-surveying on these habitats is poorlyestablished. Here, we present the first attempt to video mosaic an entire CWC mound (the Piddington Mound of the Moira Mounds, Porcupine Seabight, Irish margin) and the first attempt at standardising a cost-effective video-survey design specific to small CWC mounds in order to accurately determine the proportion of facies across their surface.

To address the specific aims of this project, the entire Piddington Mound surface has been imaged by downward-facing ROV HD video in 2011 and 2015. The mound has also been surveyed by high resolution, ROV-mounted multibeam echosounder. The HD video is automatically mosaicked and georeferenced. The mosaic is divided into 18,980 0.25 m^2 cells with a manual classification applied to each within a geographic information system (GIS). Geospatial analysis shows that cell distribution is not random but clustered significantly across the mound surface. These clusters of cells make up a ring-like facies pattern. A model for the processes that lead to this facies pattern is suggested based on contemporary environmental controls.

Further, in knowing the exact proportion of facies across the mound surface, the minimum number of random downward-facing images from the mound are determined to accurately characterise mound surface facies proportions. This minimum sample size is used to test the effectiveness of various common survey designs for ROV-video-based habitat investigations. Single-pass video lines are not representative of the mound surface whilst gridded survey designs yield best results, similar to 100% mound coverage. The minimum sample size and manual classification are applied to the 2015 video data to show a 19% mound surface facies change over 4 years at 0.25 m^2 resolution. The proportion of live coral facies show little change while coral rubble facies show most change. This highlights an inconsistency between temporally-separated data sets and implies that in 20 years, the mound surface may almost entirely change.

SAND GENERATION IN THE TIBETAN REACHES OF THE INDUS RIVERS (WESTERN HIMALAYA)

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We use petrographic and mineralogical data on modern sands from all major tributaries of the upper Indus in Tibet and Ladakh, including the Shyok River, to investigate the dependence of sediment composition on the diverse lithologies of source terranes and erosional regime of catchment areas in semiarid climatic conditions.

The Indus River is one of the largest rivers in the southern Asia and drains the Zanskar Range of NW India, the Ladakh Transhimalaya and Shyok suture zone in its upper course. Detrital modes allow us to distinguish sediments carried by northern tributaries draining the Ladakh Batholith (Dissected Magmatic Arc Provenance) from sediments carried by southern tributaries draining forearc sediments of the Indus Group and partly the Dras-Nindam subduction complex, as well as the deformed passive continental margin of the Indian sub-continent and HP-UHP metamorphic rocks of the Tso-Morari dome (Axial Belt Provenance).

Statistical methods were used to evaluate changes in composition of trunk-river sands downstream of confluences and calculate the relative contributions from each major tributary by forward end member modelling of integrated petrographic and heavy-mineral data.

Indus sand upstream of the Gya confluence displays litho-feldspatho-quartzose metamorphoclastic composition with moderately rich heavy-mineral assemblage including amphibole, garnet, clinopyroxene and epidote, indicating mixed contributions from the Tibetan Plateau, Transhimalayan batholiths, suture zones (e.g., Nidar Ophiolite) and Tso Morari Dome.

Downstream of the Gya confluence, sands become feldspatho-quartzo-lithic sedimentaclastic with a decrease of heavy-mineral concentration and increase of horneblende and epidote indicating significant recycled detritus from southern tributaries draining the Indus Group and heavy-mineral rich sands carried by northern tributaries draining the Ladakh Batholith. Composition changes abruptly downstream of the Zanskar confluence, where Indus sand becomes feldspatho-litho-quartzose carbonaticlastic with a sharp increase in carbonate grains from the Tethys Himalaya and in garnet and fibrolitic sillimanite from the Greater Himalaya.

Further downstream, rich heavy-mineral assemblages remain characterized by hornblende, sillimanite and garnet. Greater-Himalaya-derived metamorphic minerals decrease, reflecting progressive dilution by tributay supply including mafic and ultramafic detritus from the Dras-Nindam subduction complex and Spongtang Ophiolite carried by the Yapola and Sangeluma rivers. Petrographic and mineralogical data, combined with geomorphological analyses allow us to quantify the relative contributions from each tributary and geological unit to the total sand flux, and consequently evaluate sediment yield and modern erosion rates in opposite sides of the suture zone.

DEPOSITIONAL ARCHITECTURES AND EVOLUTION OF INNER SHELF TO SHELF MARGIN DELTA AND PRODELTA FAN DEPOSITIONAL SYSTEMS SINCE THE LATE OLIGOCENE IN THE PEAR RIVER MOUTH BASIN, NORTHERN SOUTH CHINA SEA

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Inner shelf to shelf margin delta and prodelta fan depositional systems developed in the Pear River Mouth Basin since the Late Oligocene in the northern continent margin of the South China Sea comprise the most important petroleum reservoirs in the basin and their evolution reflects the constraint of tectonic, sea level change and sediment supply. Based on integral analysis of abundant seismic, well logging and drilling core data, depositional architecture and evolution of these delta systems and their responses to the interplay of various controlling factors are investigated. Inner shelf deltaic systems deposited in shallow water environments are characterized by relatively thin delta forests (20-40 m), thickly stacked distributary channel fills, relative coarse river mouth bar deposits and thin distal delta front and prodelta deposits. In contrast, outer shelf to shelf-edge deltaic systems formed in deep water settings are characteristic of thick (300-1000 m) and steep (4-60) of deltaic front deposits or clinoforms, which commonly display on 3D seismic profiles as S-shape or tangent progradational reflections. Soft-sediment deformation structures, slump or debris flow deposits are commonly observed in the delta front to prodelta deposits. Associated sandy turbidite fan deposits are usually found along the prodelta slopes. The delta systems of the Late Oligocene to Quaternary underwent several regional transgressive-regressive cycles from shelf edge to inner shelf setting in the study area, and they were obviously controlled by interplay of tectonic, sediment supply and sea level change. The megacycle of shelf-edge delta systems of the Late Oligocene to Early Miocene is regarded as a “lithospheric breakup sequence”, which was mainly constrained by large sediment input from strongly uplifted drainage area and transgression related to early postrift subsidence. Development of the shelf edge delta systems during the Pleistocene were mainly attributed to sea level fall related the glaciation and large sediment supply enhanced by climatic condition. The shelf margin deltaic and associated prodelta fan deposits have proven to be the most important oil/gas bearing reservoirs in the continental margin area.

THE IMPACTS OF DEPOSITION AND DIAGENESIS ON SWEET SPOT IN TIGHT GAS RESERVOIR: AN EXAMPLE FROM XIHU DEPRESSION, EAST CHINA SEA

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The Upper Huagang Formation sandstones (3400-4400 m) are important reservoirs for large accumulations of natural gas. These sandstones exhibit wide heterogeneity in porosity (1.2-23.3%) and permeability (0.023-850 mD) related to depositional and diagenetic features. The better understanding of relations induced heterogeneity is the key to predict the 'sweet spots'. This study is aimed to determine the impact of depositional characteristics on the diagenetic evolution, and establish the collective controls on reservoir quality by detailed core description and various petrographic analysis.

Primary depositional fabric exerts a strong control on reservoir quality. In study area, the deposition of underwater distributary channel constitutes the main body of thick-overlapping sandstone reservoirs in the braided-river delta front while sandstone from other facies can be rarely preserved. The wide range of porosity and permeability is primarily driven by the petrofacies classified by mineralogical, textural and sedimentary structures. Besides, diagenesis has also significantly impacted sandstone reservoir quality. Relatively poor reservoir quality are due to severe compaction of a deep burial depths (> 4 km) and relatively abundant content of authigenic quartz, carbonate and clay ce-ment. Conversely, good reservoir quality is linked to a relatively shallow burial (< 4 km) and the presence of locally medium-thickness chlorite rim or secondary porosity developed well with abundant primary porosity.

The impacts of deposition and diagenesis on sweet spot in tight gas reservoir is not isolated part, but a closely related combination. The best reservoir quality is observed in massive or faintly laminated graded sandstones classified into medium-grained to coarse grained feldspar quartzite with less than 5% clay content. The depositional features of good-sorting and high compositional maturity promote strong dissolution and pervasive quartz overgrowth generated by chemical compaction, and thin chlorite rim and small amounts of illite have a slight effect on reservoir quality, so abundant primary and secondary porosity can be preserved. The lower-level reservoir quality is observed in cross bedding and prominent parallel bedding sandstones classified into fine to medium-grained lithic arkosic or feldspathic litharenite with 5%-10% clay content. The occurrence of bedding results in small-scale internal heterogeneity where detrital matrix and finer detrital grain arranged directionally. The finer laminate favors stronger compaction and hinders early pore-filling cement precipitation that helps the preservation of local primary porosity in the coarser grained laminate. The poor reservoir is observed in silt to very-fine sandstone with low quartz, high clay content or the coarser grained conglomerate with poor-sorting gravel or high mud clast content. Stronger compaction and cementation accelerate the densification process in the earlier diagenetic stage, so few primary porosity can be preserved.

This study demonstrated that the variations of diagenetic sequence and intensity in different petrofacies are attributed to differences in depositional characteristics, and ultimately resulting in differences in cement content and pore type that have a material impact on reservoir quality.

GEOMORPHOLOGY-SEDIMENTOLOGY PROCESSES OF PLANFORM MIGRATION ARCHITECTURE OF MEANDERING CHANNEL: FROM MODERN TO ANCIENT FLUVIAL SYSTEMS

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Geomorphology migration process and sedimentary evolution of the fluvial systems are the basis of the reconstruction and restoration of the paleochannel, as well as the premise role for forecasting the migration trend of a river. However, in long terms, the Geomorphology and Sedimentology in their respective fluvial fields develop with relative lack of combinations. With the intention to combine these two important fields and complement each other, in this paper, the theory of the geomorphologic process of the meandering river is applied to the sedimentology characteristics. The regularity of the geomorphology migration architecture of meandering river is figured out, and high-resolution historical satellite images are acquired primarily through Google Earth and ACME Mapper. Through the fine feature characterization for Irtysh River, Nowitna River, Lubilash River and Mamoré River, which are both considerably in commendable preservation condition of the natural structure, 28 kinds of architecture elements are utilized to demonstrate the structure of meandering channel. Moreover, 5 kinds of characterization parameters are proposed to make quantitative characterization, extraordinarily, the difference of along-current deflection angle ($\Delta\theta$), the difference of counter-current deflection angle ($\Delta\theta$'), and expansion coefficient (KM), these three are firstly brought forward and applied here. In addition, the conception of sinuosity index (S) and curvature (C) are also different from the previous definition and more meticulous. Specifically, via the fine anatomy of the structure of 24 typical meander loops from 200 reaches, 6 kinds of planform migration architectures are attained: Symmetrical Expansion Structure, Upstream Rotation Expansion Structure; Downstream Rotation Expansion Structure; Symmetrical Constriction Structure; Upstream Rotation Constriction Structure; Downstream Rotation Constriction Structure. Ultimately, 9 meandering channel migration patterns are concluded and discussed. Combined with the idea of geomorphological quantitative characterization, the directive significance is discussed from modern to ancient fluvial systems with the universal law and guiding role, so that to promote the geomorphology process and fluvial sedimentology onto the commonly intermingling development.

SUBMARINE CANYONS MORPHOLOGY AND FAILURE PROCESSES ALONG THE CONTINENTAL SLOPE OF THE NORTHWESTERN FOZ DO AMAZONAS BASIN, BRAZIL

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The Foz do Amazonas basin (Amazon River mouth) located on the Brazilian Equatorial Atlantic margin is intensely affected by mass-wasting processes encompassing all forms of submarine slope failures.

Failure processes are expressed in a large scale by the deposition of Mass Transport Complexes (MTC) affecting the NW and SE flanks of the Amazonas fan. In a local scale, mass-wasting processes occur along the continental slope through the development of submarine canyons associated to different types of slope instabilities. In this area, slump and slide scars can be locally very abundant at canyon heads and flanks suggesting that canyons are affected predominantly by gravitational processes.

The analysis of bathymetric and 3D seismic data revealed the details of slope failure scars and submarine canyons morphology. Canyons have amphitheater shaped heads and most of them erode the shelf break. The density of canyons and failure-scars increases to the south-east following a northwest-southeast trend along the continental slope. Additionally, seismic profiles show that canyons observed in the presentday seafloor are long-lived canyons and they have been built during the Plio-Quaternary through successive retrogressive failures that occurs on canyon heads and flanks.

These observations are consistent with the increasing subsidence induced by the deposition of the Amazon Fan, which played an important role on promoting tilting along the platform and consequently increasing slope gradient southeastwards

THE DYNAMICS OF WORM TUBE REEFS: FIELD, LABORATORY AND ANALOGICAL MODEL ANALYSES

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Sedentary polychaetes *Sabellaria spinulosa* (Leukhart, 1849) and *Sabellaria alveolata* (Linnaeus, 1767) are suspension feeders that build tubes by cementing together terrigenous particles. Often they form impressive reefs containing thousands of worm tubes. We have analysed their biocostructions in two sites along the coastal areas of the southern Adriatic Sea and central Tyrrhenian Sea where they form large and stable reefs. In this work, the results of field analyses and laboratory procedures are shown. Biological and sedimentological monitoring procedures have been carried out with a seasonal cadence in different years.

Large scale samples of the reefs have been investigated to evaluate the kind of terrigenous particles involved in the worm tube constructions; detailed grain-size and petrographic analyses were carried out on both reef and soft-sediment substrate samples. We have demonstrated that *S. spinulosa* and *S. alveolata* select sands on the basis of their grain size and shape, and not their composition. Furthermore, SEM and chemical tomography analyses allow us to describe in detail the chemical and physical features of the mucous substance that cements the grains and the general 3D structure of the worm tubes. Analogical modelling in test tank has been carried out to establish the main physical properties of the worm tubes in simplified environmental conditions (such as monomineralic grains, different bioclastic/lithoclastic percentages, duration of turbulent flows, etc.). Using the whole of these data we are able to establish the differences between the reefs of the two worm taxa in terms ofthe variations in tubes density, the relationships between grain-size and diameter of the tubes, the arrangment of the grains in the tube structures and the thickness and distribution of the worm mucus film that agglutinates the sand grains. Finally, the temporal and spatial dynamics of the reefs can be described as follow: the degradation stages seem to be related mainly to physical processes (wave, tide and current action), while the reef growth is the result of the interaction between ecological and physical processes.

A FIRST STEP TOWARDS RECONSTRUCTING RIVER DISCHARGE FROM MAJOR ELEMENT GEOCHEMISTRY: RELATIONS BETWEEN GRAIN-SIZE AND SEDIMENT GEOCHEMISTRY IN WESTERN PATAGONIAN RIVERS

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Since the discovery of the relation between sediment particle size and water flow velocity about 80 years ago, grain-size has been used as a tool to reconstruct hydrodynamic changes in various sedimentary environments. Sediment grain-size, however, also has a significant influence on sediment geochemistry. With the advent of XRF core scanners to analyze the geochemical composition of sediment cores at high resolution, sediment geochemistry is increasingly used to reconstruct hydrodynamics. The influence of grain-size on sediment geochemistry is mostly related to the association of specific elements with minerals of different sizes, shape and density. In fluvial environments, these physical properties always directly influence particle transport and deposition, hence affect the elemental composition of sediments. Better understanding the relations between sediment grain size and geochemistry is therefore crucial if we are to use XRF core scanner data to reconstruct river hydrodynamics.

Northern Chilean Patagonia is an ideal region to assess the relations between river sediment grainsize and major element geochemistry. The regional lithologies are rather homogenous and clearly distributed, with the North Patagonian Batholith dominating the western Andes, and the Eastern Andean Metamorphic Complexes and Mesozoic volcanic domain located to the East. In addition, the region is covered by Holocene andosols that are regionally highly variable in thickness. Due to the cold climate conditions, chemical weathering is weak and river sediment geochemistry is mostly controlled by hydrodynamic sorting.

For this study, bulk river sediment samples were collected from the mouths of the six main rivers draining the region between 44 and 48°S (Cisnes, Aysen, Pelu, Exploradores, Gualas and Baker). The river sediment samples were sieved into 11 grain-size fractions between < 4 and 250–500 µm, and analyzed for major element geochemistry and mineralogy. Results show that grain size influences all major elements but to different degrees. Of all the measured elements, Al is the most unaffected, with variations with grain size of less than 10%. All the other elements were therefore normalized to Al to assess the influence of sorting on sediment geochemistry. All six rivers show significant enrichments of Zr/Al in silts (watersheds covered in thick andosols) to very fine sands (watersheds with thin/no andosols), with increases of up to an order of magnitude. Likewise, Ti/Al peaks in the coarse silt and fine sand fractions, with no significant influence of provenance, while Na/Al and Ca/Al tend to slightly increase with grain-size across the entire particle size spectra. This study suggests that Zr/Al and Ti/Al are the elemental ratios most sensitive to grain-size, and that each elemental ratio is sensitive within its own specific grain-size range. One single elemental ratio can therefore not fully represent grain size across the range generally encountered in nature, and it is necessary to combine several elements or elemental ratios to fully represent the grain-size variations observed in natural sedimentary environments. In the future, we intend to develop a statistical model based on all the log-transformed elemental ratios into one single grain-size index.

SEQUENCE STRATIGRAPHY AND QUATERNARY DEPOSITIONAL SYSTEMS IN SANHU AREA, QAIDAM BASIN, NORTHWEST CHINA

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Qaidam Basin is a Mesozoic–Cenozoic compresso-shearing basin in Western China. This basin has been subsiding since the Indosinian orogeny; subsidence was a strong inherited feature in its Quaternary development. According to previous studies, the criterion of sequence division is inconsistent; many bifurcations exist in types of sedimentary facies and distribution of sequence stratigraphy.

Two sequence-filling models were built and five third-order sequences (sq1, sq2, sq3, sq4, and sq5) were recognized through comprehensive methods, including drilling/logging, coring, and seismic data analysis. Sequence stratigraphic framework has been established and distribution of sedimentary system has been revealed. Eight sedimentary facies have been identified, including alluvial fan, fan delta, braided delta, shore lacustrine, shallow lacustrine, and others, by combining data from 105 well logs and 2D seismic lines consisting of hundreds of km. The revealed sedimentary system distribution are as follows: large-scale alluvial deposit located on south slope and adjacent to Kunlun Mountain and Yaber tectonic zone northeast of the study area; beach bar depositional system lacking terrigenous supply distribution in Sebei tectonic zone; and widely distributed shallow lacustrine facies. Shoal lacustrine facies are well deposited along depositional strike in regressive systems tract in contrast to the narrowly distributed shallow lacustrine facies. Incised valley has a large lateral extension and incision depth as an entity in front of the Golmud basin ward in Sanhu area. Two different depositional models, namely, east and west models, were built through the integrated analysis of sequence stratigraphy and sedimentary process.

The study area was in a special salted lacustrine environment and had a unique lithological association, paleogeomorphology, and paleoenvironment because of the structural rising in Quaternary. Therefore, this case study provides an example of the analysis of sequence stratigraphy and depositional system in a salinized plateau basin. Quaternary sediment characteristics of loose deposits, complex lithofacies, and low diagenetic stage increase the difficulty in establishing sequence stratigraphic framework and constructing depositional systems. Thus, this study also provides a combination of seismic facies and sedimentary facies analytical methods to investigate Quaternary deposition and stratigraphy. Furthermore, the gentle slope located in the transition area between prodelta and semi-deep lake facies in the Sanhu area is favorable in forming a lithologic gas reservoir.

ESTIMATION OF PALAEO-SLOPE AND SEDIMENT VOLUME OF A LACUSTRINE RIFT BASIN: A SEMI-QUANTITATIVE STUDY ON THE SOUTHERN STEEP SLOPE OF SHIJIUTUO UPLIFT BOHAI OFFSHORE BASIN, CHINA

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The sequence architecture and depositional systems of the Palaeogene lacustrine rift succession in the southern steep slope of the Shijiutuo Uplift (SU) in Bohai Offshore Basin (BOB) were investigated using combined 3-D seismic, well log and core data. Four second-order/composite sequences and seven third-order sequences were identified. A detailed analysis revealed fan delta, braid delta and lacustrine depositional systems in the third-order sequences 7 (SQ7). Eleven seismic facies were chosen in the SQ7 to calculate the area and sediment budget. We also calculated the palaeo-slope parameters in the southern steep slope of SU, including the gradient of basin margin fault slope belt, the shape, average width, average height, width/ height ratio and cross sectional area of palaeo-valley. The gradient of the fault slope break belt was inversely proportional to the area and volume of sediments. The higher gradient corresponded to the smaller area and volume of sediments. The width and cross sectional area of palaeo-valleys dominated the volume and facies of sediments. A larger cross sectional area of a palaeo-valley involved much more sediments supply and more favorable conditions for the origin of large-scale deltas. Because of favorable sediment transportation path and existence of large-scale braid delta, the eastern part of the SU formed better quality reservoir than that in the west.

SEDIMENTARY ARCHITECTURE OF A SUB-LACUSTRINE DEBRIS FAN: EOCENE DONGYING DEPRESSION, BOHAI BAY BASIN, EAST CHINA

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The sedimentary architectures of submarine/sublacustrine fans are controlled by sedimentary processes, geomorphology and sediment composition in sediment gravity flows. To advance understanding of sedimentary architecture of debris fans formed predominantly by debris flows in deep-water environments, a sub-lacustrine fan (i.e., Y11 fan) within a lacustrine succession has been identified and studied through the integration of core data, well logging data and 3D seismic data in the Eocene Dongying Depression, Bohai Bay Basin, east China. Six types of resedimented lithofacies can be recognized, which are further grouped into five broad lithofacies associations. Quantification of gravity flow processes on the Y11 fan is suggested by quantitative lithofacies analysis, which demonstrates that the fan is dominated by debris flows, while turbidity currents and sandy slumps are less important. The distribution, geometry and sedimentary architecture are documented using well data and 3D seismic data. A well-developed depositional lobe with a low aspect ratio is identified based on a sandstone isopach map. Canyons and/or channels are absent, which is probably due to hydroplaning of debris flows. Distributary tongue-shaped debris flow deposits can be observed at different stages of fan growth, suggesting a lobe constructed by debrite tongue complexes. Within each stage of the tongue complexes, architectural elements are interpreted by wireline log motifs showing amalgamated debrite tongues, which constitute the primary fan elements. Based on lateral lithofacies distribution and vertical sequence analysis, it is proposed that gravity transformation, entrainment and dilution in the flow direction lead to an organized distribution of sandy debrites, muddy debrites and turbidites on individual debrite tongues. Plastic rheology of debris flow combined with fault-related topography are considered the major factors that control sediment distribution and fan architecture. Furthermore, a debris fan model was proposed by synthesizing the sediment supply, flow types, local topography and depositional processes. An important implication of this study is that a deep-water depositional model for debrite–dominated systems was proposed, which may be applicable to other similar deep-water environments.

CHEMO-SEDIMENTARY FACIES ANALYSIS: AN INNOVATIVE APPROACH FOR CHARACTERIZING FINE-GRAINED SEDIMENTARY ROCKS

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Unconventional petroleum systems, such as shale oil and gas reservoirs, are primarily dominated by fine-grained sedimentary formations. Characterization of unconventional petroleum reservoirs has traditionally been hampered by the lacking of adequate and effective techniques at macro-micro scales because conventional sedimentological techniques such as visual observation and optical microscopy can no longer discern key compositional and depositional features due to their fine-grained nature.

An innovative methodology, called “chemo-sedimentary facies analysis”, has been developed to effectively characterise fine-grained sedimentary formations. The method involves an integration of optical images with 2D elemental maps of core samples of decimeter dimensions scanned at micrometre resolution. Concentrations of desired elements can be obtained relatively rapidly with spatial resolutions of 25 mm with a micro-XRF scanner or sub-micron using SEM imaging with EDS (Energy-dispersive spectroscopy). This allows an effective spatial mapping of (1) mineral compositions and lithological facies; (2) sedimentary structures and textures, (3) fine rhythmic beds and sedimentary cycles down to mm-mm scales. By combining vertical profiles of elemental concentrations and ratios, it is possible to differentiate sediments of in situ precipitation from terrestrial input, determine depositional rate, palaeo salinity and palaeo water depth or even infer (6) palaeo climatic settings and TOC abundances.

The methodology was employed to investigate a Permian shale oil sequence in the Jimusaer Sag of the Junggar Basin, western China. Two sweet spots/intervals have been successfully delineated based on the technique. The interval is characterised with fractured calcareous (primarily calcite and dolomite with minor siderite) intervals providing keystorage space and migration conduits, whereas the interbedded albiterich intervals provide numerous dissolution pores and pressure solutions (sutures) at sedimentary interfaces, where high-TOC source rocks are often present. The coupling of the brittle calcareous interval and the ductile albite and organic-rich interval provides an ideal combination for shale oil production via horizontal drilling and hydraulic fracturing.

It has been demonstrated that the newly proposed “chemo-sedimentary facies analysis” technique can effectively capture sedimentary heterogeneities at macro-micro scales and provide hitherto unmined compositional and structural information directly from core samples that can be used to deduce depositional environments and determine lithofacies of fine-grained sediment formations. This technique may have a wide application in the investigation of unconventional petroleum systems.

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DIAGENESIS OF THE SILICICLASTIC PERMIAN ECCA GROUP SANDSTONE

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The Ecca Group in the southern Main Karoo Basin is of particular interest for hydrocarbon exploration in South Africa, which is of Permian age and deposited in marine environment. To date, there is lack of diagenetic study on the sandstone despite the fact that the sandstone is a potential unconventional hydrocarbon reservoir rock and diagenesis is a major factor that affects reservoir rock property. This study aims to provide new insight on the diagenetic evolutionary processes of the Ecca Group and provide a case study for diagenesis of siliciclastic rock of marine origin.

The diagenetic processes of the Ecca Group can be categorised into four stages, which are early diagenesis, shallow burial diagenesis, deep burial diagenesis and uplift diagenesis. Six types of cements were found in the sandstone, which are dominantly smectite and quartz cements, with fewer amounts of kaolinite, hematite, calcite and feldspar cements. In the early diagenetic stage, clay and quartz cementation, and initial compaction largely reduced the porosity of the sediments; authigenic quartz, pyrite and smectite/illite clays were formed within the sediments. In the shallow burial diagenetic stage, quartz and feldspar overgrowths started to form; point and long grain contact, more compaction and mineral recrystallization were developed; clay mineral conversion from smectite/kaolinite to illite and then sericite were created. In the deep burial diagenetic stage, recrystallization of clay and quartz minerals, concave-convex and suture grain contact, chloritization, pressure-solution and stylo-lite, grain deformation and fracturing, and calcite replacement and albitization occurred. In the uplift stage, dissolution pore and cracks, saussuritization, decementation, evaporative caliche, oxidation and weathering of Fe-Mn rich minerals and secondary load-relieving crack and fracture were created. The sandstones were subjected to moderate-intense mechanical and chemical compaction during their progressive burial. Primary intergranular pores, secondary dissolution and fractured pores are developed in the sandstones. The primary porosity is relatively lower in the Ecca Group due to clay matrix and quartz cementation, but the secondary porosity is moderate due to dissolution, tectonic fractures and joints, and unroofed load-relieving weathering, which enhanced reservoir quality.

Rock-eval pyrolysis shows that the sandstones have TOC ranging from 0.11 to 7.35 wt.%. The van Krevelen diagram shows that the sandstones are of Type II and mixed Type II-III kerogen. Tmax values range from 318 to 601, whereas the vitrinite reflectance values range from 2.22 to 3.93%. Based on the geochemical data, it can be inferred that source rocks are immature to over-matured and have potential of producing natural gas in the sandstone reservoir. The basin subsidence history indicates that three major subsidence episodes characterised the Ecca Group, namely (1) rapid subsidence in an extensional regime; (2) slow subsidence in the middle of basin development; and (3) another rapid subsidence in the compressional regime.

NEW INSIGHTS INTO THE RECENT BOTTOM-CURRENT PROCESSES WITHIN THE LE DANOIS INTRASLOPE DOMAIN (CANTABRIAN CONTINENTAL MARGIN, NE ATLANTIC)

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Contourite deposits are sediments deposited or reworked by the action of bottom-current processes. Around the Iberian continental margin, plenty of morphological features are formed by this specific process. The Le Danois intraslope basin is located along the Cantabrian continental margin, southern Bay of Biscay. In this margin it has been identified the Le Danois Contourite Depositional System (CDS) which is unique due to its local morphologic control and the interaction with different water masses.

This contribution aims to illustrate the variety of recent bottom-current dynamic processes based on the interpretation of local geomorphologic features by multibeam bathymetric data and a unique network of reflection seismic profiles, respectively obtained by TOPAS, single channel sparker and multichannel airgun systems. Morphological features have been correlated with regional oceanographic processes identified by CTD data. In the region, the water mass stratification contains the Eastern North Atlantic Central Water (ENACW) between 300-650 m, the Mediterranean Outflow Water (MOW) between 750-1550 m and the Labrador Sea Water (LSW) between 1750-2000 m. The core of the MOW is located at 1000 m water depth, where it reaches maximum where it reaches maximum salinity (~35.8 psu) while potential temperature almost stalls at about 10°C. It is supposed to enter the area from the western edge of the intraslope basin and flows eastwards, though blocking due to recirculation and westwards flow have also been observed.

Different morphosedimentary features have been mapped. Four plastered drifts and many slide scars are recognized on the southern flank of the Le Danois Bank. The Le Danois Moat (800-1550 m water depth) and an elongated mounded and separated drift expand from west to east along the southern foot of the bank. The W-E trending Central Moat (850-970 m water depth) and a confined drift are identified at the central part of the intraslope basin. In addition, two upslope-growing sediment wave fields (with a wave length of 370-1020 m) are respectively located at the eastern edge of the Central Moat and the southern edge of the confined drift. At the southern edge of the intraslope basin, the Gijón Moat (450–1100 m water depth) follows the contour lines from west to east. An elongated mounded and separated drift (450-1080 m water depth) is bordered by the Gijón Moat. Between the intraslope basin and the continental shelf break, two plastered drifts are recognized.

The interaction between the bottom current circulation and the seafloor is responsible for the morphologic features presented in this study. The Le Danois Moat, the Central Moat, the Gijón Moat, the confined drift and two elongated mounded and separated drifts are the results of the MOW interaction with the seafloor. Two sediment wave fields are respectively located at interface between the ENACW and the MOW and interface between the MOW and the LSW. When the interface between water masses reaches the seafloor irregularities, the turbulence of the internal waves may generate sediment waves.

SEISMIC ARCHITECTURE AND EVOLUTION OF THE LE DANOIS BANK CONTOURITE DEPOSITIONAL SYSTEM (CANTABRIAN CONTINENTAL MARGIN, NE ATLANTIC)

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The Le Danois intraslope basin is located at the Cantabrian continental margin in the southern Bay of Biscay. The origin of the basin dates back to the Variscan massifs of Europe in the late Paleozoic. The sediment from Cantabrian mountains started to infill the basin since the Triassic. The Le Danois contourite depositional system (CDS) is mostly modulated by the action of the Mediterranean Outflow Water (MOW). The evolution study of this area enable to bridge the gap of knowledge between the distal and proximal MOW site.

The data used for this study is composed of single channel sparker and multichannel airgun seismic data. From old to young, six seismic units (U1 to U6) bounded by major discontinuities (H1 to H6) have been identified. Unit U1 has been deposited within the central part of the intraslope basin. It is characterized by transparent subparallel reflectors. The palaeocontour map of horizon H1 indicates the occurrence of three W-E oriented subcircular structural highs (4.2-6.3 km long, 4.4-6.2 km wide) within the intraslope basin. Unit U2 has been deposited around three structural highs. It is highlighted by chaotic reflectors. The palaeocontour map of horizon H2 is similar to the one of horizon H1. The first observation of the contouritic deposits is from Unit U3. A small-scaled plastered drift is generated adjacent to the western edge of the northernmost structural high. Weak along-slope bottom current processes modified the seafloor within Unit U3. The palaeocontour map of horizon H3 indicates a W-E trending channel-like feature (10 km long, 1.3 km wide) between the southern foot of the bank and the western edge of the northernmost structural high. Unit 4 is relatively thin due to the erosion of seafloor. The palaeocontour map of horizon H_4 is highlighted by its absence at the western edge of the northernmost structural high. Due to the morphologic control of the Le Danois Bank and three structural highs, the enhanced bottom-current processes intensively erode the seafloor in Unit U4. However, in Unit U5, depositional action of bottom currents plays a primary role in shaping seafloor. Elongated mounded and separated drifts and moats are generated in Unit U5. Slide scars and sediment waves are also formed in this unit. The palaeocontour map of horizon H5 indicates another W-E trending channel-like morphologic feature (13 km long, 1.9 km wide) at the southern edge of the intraslope basin. The plastered drifts started to generate instead of the elongated mounded and separated drifts in Unit U6. The less energetic bottom currents dominates the study area again. The palaeocontour map of horizon H6 is similar to the present bathymetric map.

A similar sedimentary stacking pattern can be identified on the Le Danois CDS compare with the Gulf of Cadiz. The strength of MOW activity changed from low energy to high energy. This study suggests that horizon H3 and H5 could be respectively associated with the base Quaternary discontinuity (BQD) and Mid Pleistocene discontinuity (MPD).

CYCLOSTRATIGRAPHIC ANALYSIS OF THE LOWER CRETACEOUS TERRESTRIAL SONGLIAO BASIN, NORTHEAST CHINA

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Recent exploration of the Songliao Basin, NE China, which is one of the largest and longlived Cretaceous continental basins in the world with a continuous 10-km-thick sequence of strata, provides new opportunities to study terrestrial climate change and to improve the Early Cretaceous time scale. Understanding the evolution of the basin, including the climatic and environmental changes that affected sediment deposition, is key to identifying the forces that led to enhanced carbon burial and preservation, leading to today's oil and gas reserves in the basin. In this study, we conduct cyclostratigraphic analysis on natural gamma-ray logs from extended boreholes in the Songliao Basin. The target is the Lower Cretaceous Shahezi Formation (K1S), a 836-m-thick succession with black and dark grey mudstone, siltstone, fine grained sandstone, gravel-bearing sandstone and conglomerate, together with meter-scale black coal units distributed throughout the upper part of the formation. The mudstones have the highest gamma-ray values and the conglomerates the lowest gamma-ray values. Time series analysis of the gamma-ray logs from selected boreholes reveals power spectra that are consistent with Earth's astronomical frequencies of precession, obliquity and orbital eccentricity, providing strong evidence for astronomically driven climate change. The results also indicate that black coal coincides with short eccentricity minima that exceed a threshold. We conclude that the age of K1S is from early Valanginian to late Hauterivian with a duration of approximately 11 million years by calculating cycle number and matching with the La2004 theoretical astronomical model. The formation may also reflect the well-known transient cooling Weissert Event in the mid-Valanginian as evidenced by marine glendonites at Svalbard Island. The cyclic evolution of the formation's lithology indicates a paleo-lake and surrounding environment that expanded and contracted repeatedly. Astronomical forcing influenced paleo-lake level: climate was warm and humid with high orbital eccentricity, and cold and dry with low orbital eccentricity. Sedimentation rates significantly decreased from lower to upper K1S as the basin evolved from synrift to post-rift conditions.

CONTROLLING FACTORS OF LAKE GRAVITY FLOW OF CHANG 7 MEMBER IN ORDOS BASIN, CHINA: INSIGHTS FROM FLUME TANK EXPERIMENTS

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Deep-water gravity flow deposition theory and experimental research are the hotspots in the field of sedimentology. The gravity flow sedimentation theory, which is represented by the continental lake basin of Chang 7 in the Triassic Yanchang Formation of Ordos Basin, has achieved good results in oil and gas exploration. Based on the system study of field profile and core observation, logging data, and deep-water gravity flow deposition theory, the genetic types of lake gravity flow deposition of Chang 7 Member in Ordos Basin are divided into sandy debris flow deposit, turbidite deposit and slump deposit. The sandy debris flow deposit is consist of gray, brown and gray massive fine-grained sandstones with a thickness of more than 0.5 m, GR values range from 51-105API, massive bedding is extremely developed, oil bearing properties are good, sediments show abrupt contact with overlying beddings and underlying beddings; The turbidite is made up by gray, dark gray siltstones, argillaceous sandstones, the thickness of a single turbidite layer is a few centimeters to tens of centimeters, GR values range from 90-137API, sandstone thin interbedding is developed, parallel bedding, small-medium cross bedding, horizontal bedding and ripple cross lamination are visible, the turbidite also possesses complete or incomplete Bouma sequence, flute cast is visible in the bottom of sandstone; The slump deposit is the least developed sand body in the research area, it is consist of siltstone and silty mudstone, convolute bedding and small fold structure are developed, brecciated mudstone rip-up clasts are visible, sliding surface is developed in the bottom, the lithology of interface is significantly different. The formation processes and main controlling factors of gravity flow sedimentary sand bodies of Chang7 Member are recreated by qualitative observation and quantitative description of simulated experiment. The experimental research indicates that the main controlling factors to impact the formation and evolution of gravity flow sedimental sand bodies are: (1) sand-shale ratio (decides the transport mechanism of fluid and the sediment type of gravity flow); (2) the shape of the bottom of a lake basin (controls the distribution of gravity flow sand body); (3) the lake level (controls the accommodation space of gravity flow sand body); (4) the flow rate (decides the scale of gravity flow sand body); (5) the subsidence of basin basement and the abundance of sediment supply (decide the enrichment of gravity flow sand body). Based on the deep-water gravity flow deposition theory and gravity flow sedimentation simulation experiment, the gravity flow sedimentary sand bodies of Chang 7 in Ordos Basin are summarized as the following distribution characteristics: (1) the sandy debris flow deposit is near source distribution, the turbidite shows a distal distribution; (2) the sandy debris flow converts to turbidite along the source direction then form to deep-water gravity flow hybrid event beds; (3) the gravity flow deposit sand bodies distributes successively in the longitudinal direction and discontinuously in the horizontal direction; (4) the gravity flow is characterized by zone distribution, it belongs to the channel type (non-fan) gravity flow sedimentary deposition system.

DIAGENESIS AND EVOLUTION OF CARBONATE KARST RESERVOIR UNDER TECTONIC UNCONFORMITY – AN EXAMPLE FROM WANJIAXIANG OUTCROP IN NORTHEN SICHUAN BASIN

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This study focus on the diagenesis and oil pooling process in tectonic unconformity karst reservoir. Previous researches have shown that there is a regional tectonic movement in early Caledonian movement, leading the exposure and erosion of the Ordovician Baota Formation in northwest of the Sichuan Basin. Limestone and bioclastic limestone are found in the karst reservoir under the unconformity, within which are abundant dissolution caves and fractures filling karst fragment, bitumen and calcite, basing on outcrop, drilling and microscope observation. Geochemistry and fluid inclusion tests have been taken on surrounding limestone and filling calcite, showing the main diagenesis and oil pooling process as follow. In Early Ordrovician, there appeared unconformity and abundant coles, in which early calcites filled soon. From Late Devonian to Early Carboniferous, oil pooled in the caves. In Late Permain, late calcites filled in the remaining coles. From Early Triassic, tectonic fractures formed and gas pooled in until Late Cretaceous. The late tectonic fractures throughout surrounding limestone and bitumen, forming migration pathway as well as main reservoir space.

QUARTZ CEMENTATION MECHANISMS AND PREDICTIVE DISTRIBUTION OF HIGH-QUALITY RESERVOIRS OF TIGHT SANDSTONES: EVIDENCE FROM HE-8 SANDSTONES OF THE SULIGE GAS FIELD IN THE ORDOS BASIN, CHINA

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The eighth member of the Lower Permian Xiashihezi Formation tight gas standstone reservoirs is the main exploration target for hydrocarbons in the Ordos basin in China.The He-8 sandstones are characterized as tight with low porosity, low permeability and strong heterogeneity. This study investigates the composition, sedimentary facies, and diagenetic history and their impact on quartz cementation and reservoir quality of the He-8 sandstones. Reservoir property, lithological components, depositional micro-facies, diagenesis, and diagenetic minerals were determined through petrographic studies including X-ray diffraction, scanning electron microscope (SEM), back scattered electron detector (BSE) image analysis and core analysis. The results show that the sandstones are dominated by quartz sandstone, lithic quartz sandstone and litharenite. The reservoir properties of the He-8 sandstones are generally poor with a porosity ranging from 2.1% to 16.38% and permeability from 0.006 to 7.76 mD, which are attributed to the significant compaction and cementation. The most common cements, which control the reservoir properties in the He-8 sandstones, are quartz cement including quartz overgrowths and authigenic micro-quartz. The amount of quartz cementation is controlled by the grain size as well as the amount of detrital quartz and diffluent-ductile-proportion (DDP) on the same conditions of temperature, pressure and burial history. Clay-induced chemical compaction and pressure dissolution of detrital quartz is probably the main process yielding silica for local quartz cement. The amount of quartz cementation increased on the larger grains and reduced on the less DDP. By linking diagenesis to depositional facies, it can be concluded that the high-quality reservoirs in He-8 standstones are associated with coarse-grained sandstones of secondary porosity and low content of quartz cements. The best reservoir quality is potentially encountered in the successive sandstone with a thickness of at least 4 m.

TRACING THE EVOLUTION OF DEPOSITIONAL SYSTEMS FROM THE LATE CARBONIFEROUS TO THE EARLY TRIASSIC IN THE CENTRAL PYRENEES (ERILLCASTELL BASIN): A TECTONO-STRATIGRAPHIC APPROACH

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The late Palaeozoic-early Mesozoic stratigraphic succession of the Central Pyrenees provides the opportunity to study the evolution of sedimentary and volcano-sedimentary units deposited in a series of intracontinental basins. The genesis of these basins starts with a permo-carboniferous postcollisional, strike-slip tectonics, followed by an Early-to-Middle Permian more extensional setting. The beginning of the Triassic deposition is recorded by the onset of a widespread extensional sedimentation in Buntsandstein facies. At this respect, our attempt aims to investigate the paleo-structural and stratigraphical picture of the Erillcastell Basin. This basin shows a well-preserved geological record that allows to directly infer the close interplay between tectonics and sedimentation, and the development of depositional systems. New stratigraphical and sedimentological data obtained, are fundamental for paleoenvironments and paleoclimatic reconstructions. We focused on the late Carboniferous volcaniclastic /pyroclastic deposits and on the "Permian red beds" due to their higher potential of correlation. A detailed tectono-stratigraphic analysis was performed following accepted stratigraphic units subdivision. The fining-upward, 600 m thick late Carboniferous-Permian succession is mostly made up of conglomerates, sandstones and siltstones with intercalations of volcanics and volcaniclastic levels. It is organized into two main sedimentary cycles that groups three depositional units. The first cycle consists of the volcanic and volcaniclastic Grey Unit (GU, upper Carboniferous) and Transition Unit (TU, early Cisuralian). The second cycle is represented by the Lower Red Unit (LRU, middle-late? Cisuralian). Both the TU and the LRU are fining-upward clastic sequences dominated by alluvial fan, meandering river floodplain and lacustrine deposits. Channels, overbank fines and palaeosols occur as the most representative architectural elements. A third sedimentary cycle is represented by the Upper Red Unit (URU, Kungurian-Wordian?) but not deposited in this area. The overlying Buntsandstein deposits (Olenekian to Anisian), represents a fourth sedimentary cycle and unconformably overlies the LRU in this area. It consists of oligomictic quartz rich conglomerates, sandstones and fines. The isopach analysis along Erillcastell Basin discloses a heterogenic distribution on each unit. The volcanic emplacements were located in two isolated sub-basins in external parts of the basin during GU times as a consequence of deep-seated transtensional faulting. The facies analysis for this unit reveals important calderas collapse deposits. In the early Cisuralian, the basin area widened due to a new extentional tectonic pulse. Following with this enlargement, incipient fluvial systems began to fill the created space with fine shallow-lacustrine deposits, under humid conditions. During the middle-late Cisuralian a subsequent tectonic pulse connected the two isolated sub-basins. Henceforth this moment, the previous humid environment shifted to more wet-and-dry conditions and the deposition was dominated by low gradient fluvial system and playa-lake deposits. At last, in the Early Triassic, the basin experienced a more extensional regime eroding the previous units and spreading over the basement heights. Meandering rivers and wide floodplains filled this space. In conclusion, the stratigraphic and sedimentological evolution of the Erillcastell Basin was strongly linked to syn-tectonic faults movements. This structural evolution led to the non-deposition of the URU which in the closest basin reaches 280 m thick.

BASIN ARCHITECTURE AND TECTONO-SEDIMENTARY INTERPLAY FROM THE LATE PALAEOZOICEARLY MESOZOIC STRATIGRAPHIC SUCCESSION OF THE CENTRAL-EASTERN PYRENEES (SPAIN): AN INTERREGIONAL PERSPECTIVE

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The late Carboniferous-Lower Triassic basins of the Central-eastern Pyrenees are the result of the post-orogenic transtension and extension after the Variscan orogeny. Several intramontane continental troughs formed in SW Europe following the Upper Carboniferous-Lower Permian crustalscale dextral shearing. In this geodynamic scenario, a strong tectonic control influenced the infills and geometries of the basins. In particular, their genesis is linked to the onset of post-collisional strike-slip tectonic regime followed, in the Cisuralian, by a more extensional setting with fluvial and lacustrine facies, accompanied by extensive pyroclastic deposition. Small and elongate fault-bounded basins expose a complete Late Palaeozoic continental volcano-sedimentary succession sealed by the widespread extensional Triassic sedimentation. The Upper Carboniferous–Lower Triassic stratigraphic record has been organized in four major sedimentary cycles grouping five litostratigraphic units. From oldest to youngest: the Grey Unit (GU – Upper Carboniferous), the Transition Unit (TU – earlyLowerPermian), the Lower Red Unit (LRU – late Lower Permian), the Upper Red Unit (URU – early Middle Permian) and the Buntsandstein facies (BUNT – Lower-Middle Triassic). The tectono-stratigraphic evolution of four Upper Carboniferous – Lower Triassic basins was analyzed in Central-eastern Pyrenees. In order to better characterize each basin, this research is focused on multidisciplinary approach, linking sedimentology, tectonics, paleontology, and radiogenic isotope analysis. From W to E the four basins studied are the Castejón-Laspaúles, Erillcastell, Gramós, and Castellar-Camprodón. New stratigraphic data show some differences between the basins. Among others, the absence of the URU in the more westerly areas (i.e. ErillCastell and Castejón-Laspaúles) represents an important issue. Despite paleotopographic highs isolating the various sub-basins, other important fact is the single unit's thickness variation inside the troughs. From west to east, only the basal GU looks deposed with homogeneous hectometer thickness with only local variations. The three Permian units (TU, LRU and URU) are thinner towards the west up to areas where the URU is completely lacking. The important syn-tectonic fault control in the western strike-slip basins together with the performed structural analysis indicate that the URU never deposited in those basins.

From our detailed sedimentological study in the Erillcastell, Gramós and Castellar-Camprodón basins, we can state that: 1) the Upper Carboniferous-earliest Permian deposits show very similar features in all of them; 2) during the Early Permian, coarse-grained sediments and more channelized deposits developed in the eastern-central basins, i.e Castellar-Camprodón and Gramós and became finer and related to sand flats or playa-lake settings to the west; 3) the Buntsandstein shows again homogeneous facies and thicknesses everywhere.

As a whole, the geological evolution in this wide context can be assumed as a proxy to understand the tectono-stratigraphic basin history as a consequence of a post-collisional regime in the collapse phases of an orogenic chain. In particular the Erillcastell Basin is a very good reference to show how tectonics controls the sedimentary deposition during the final stages of the Variscan orogenesis.

THE MESSINIAN SALINITY CRISIS SCENARIOS: WHAT OFFSHORE SEISMIC RECORDS TELL US

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Despite 40 years or multi-disciplinary research, the Messinian Salinity Crisis (MSC) event remains one of the longest-living controversies in Earth Science. Several conceptual models have been proposed to account for the genesis of the Mediterranean salt giant within a short time span, ranging from salt emplacement in deep water under moderate base level drop to salt emplacement associated to a large sea level fall and synchronous erosion of deeply incised valleys in the margins. A key factor for such contention between the proposed scenarios is partly due to the fact that the MSC triggered a sedimentary/time lag on the continental shelves and slopes corresponding to a widespread erosional surface. The correlations are thus complex between depositional units, now outcropping onshore in tectonically active areas, and deep basin records, preventing the construction of a coherent scenario at the basin scale.

The MSC has mainly been, and is still mainly studied through the analysis of outcrops although these provide incomplete records, most of the time of successions accumulated in shallow water settings. The MSC has also been studied through marine seismic profiles offshore, allowing the imaging of the entire MSC records from the continental margins down into the deep basins. However, seismic profiles bear a much lower resolution than the outcrop analyses, and lack chronostratigraphic and lithologic controls in the absence of full core recovery of scientific boreholes. As a consequence, MSC scenarios are mainly based on the onshore records.

Modern geophysical data allow imaging the MSC markers (erosional surfaces, depositional units and their bounding surfaces) much better than in the past and still are the only way to address the temporal and spatial organization of these markers at a large scale (i.e. the Mediterranean basin and its sub-basins). We thus believe that seismic records are under-considered in the elaboration of current MSC scenarios. The offshore records raise the following issues that should be taken into consideration in any attempt to explain the MSC in a coherent way at the Mediterranean scale: 1) the Messinian erosional surface and associated evidence for large amplitude sea-level lowering are not adequately taken into consideration ; 2) the role played by gateways and intra-Mediterranean sills in evaporite emplacement (and more largely on the spatial variability of the MSC records) is under estimated in current studies; 3) recent observations from the Balearic basin highly suggest that the current chronostratigraphic scenario largely based on the Sicilian salt records and considering that these are representative of the deep basin history (e.g., so called stage 2 and 3 of Roveri et al., 2014) are unlikely; 4) existing models assume well-mixed water columns, when stratified water columns are required for evaporite deposition.

THE "DREAM" IODP PROJECT TO DRILL THE MEDITERRANEAN SALT GIANT ON THE BALEARIC PROMONTORY

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Salt giants preserving kilometer-thick evaporite layers are the sedimentary expression of extreme environmental events of global relevance. Despite their global occurrence and general importance on Earth, there is currently no complete stratigraphic record through an un-deformed salt giant of marine origin. Similarly, there is a significant lack of knowledge about the factors controlling salt giants deposition, their early evolution, the impact they exert on the isostatic response of continental margins and on sub-salt formations, and the unprecedented deep biosphere they may harbor. The Mediterranean Messinian salt giant, which formed ~5.5 Myrs ago, is one of the youngest salt giant on Earth and is currently lying below the Plio-Quaternary cover in a relatively un-deformed state close to its original depositional configuration. This salt giant is thus accessible by drilling and forms an ideal case study that could be used as a reference for older salt giants. However, since its discovery in 1970 during the DSDP Leg XIII, and despite 40 years or multi-disciplinary researches, this salt giant is still not fully understood and remains one of the longest-living controversies in Earth Science.

In this context, the IODP DREAM project aims at exploring the Mediterranean salt giant by drilling with the JOIDES Resolution a transect of 4 sites on the southern margin of the Balearic promontory (Western Mediterranean). We identified this area as likely the only place in the Mediterranean where we could implement a shallow-to-deep transect of non-riser drilling sites. Due to the geological history and pre-structuration of the Promontory, MSC deposits are found preserved in a series of sedimentary basins lying at different water depths between the present-day coastline and the deep central salt basins. DREAM thus offers a unique opportunity to sample several hundred of meters of material forming the Mediterranean salt giant in varied water depths. This unique sedimentary record should allow testing 1) the contradictory emplacement models that explain its genesis and 2) the presence of halophilic micro-organisms it may host/feed.

Acknowledgments: DREAM is a part of a bigger Multi-phase IODP Drilling Project entitled "Uncovering a Salt Giant" (857-MDP, coord. A. Camerlenghi) born out of a serie of workshops and international initiatives carried out since 2014. The DREAM pre-proposal P857B has been accepted by the IODP Science Evaluation Panel in January 2016. The full-proposal will be submitted after the acquisition of complementary Site Survey Data in 2017. The DREAM project is performed in close link with various international initiatives including the COST Action CA15103 (coord. A. Camerlenghi), the ANR Project MEDSALT, the European ITN Salt Giant (coord. G. Aloisi), the IMMAGE ICDP-IODP amphibious proposal (coord. R. Flecker) and the IODP Levant basin drilling project (coord. C. Bertoni).

ORIENTATION OF MAGMATIC DYKES AND IMPACT-INDUCED FAULTS IN THE PEAK RING OF THE CHICXULUB CRATER INFERRED FROM BOREHOLE IMAGING

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The Chicxulub impact crater formed ~65.5 My ago and is currently buried below post-impact sediments. It is the only known terrestrial impact structure directly linked to a mass extinction event (K-Pg) and presenting an intact, unequivocal topographic peak ring. In 2016, in the framework of IODP (International Ocean Discovery Program) and ICDP (International Continental Scientific Drilling Program), the mission specific platform Expedition 364 drilled a ~1.3 km deep borehole at Site M0077A into the crater's peak ring. It allowed recovery of 303 excellent quality cores from 505.7 to 1334.7 meters below sea-floor and the acquisition of ~6 km of open hole logs. The first expedition results published in "Science" (Morgan et al.,2016) argue that the drilling confirms the dynamic collapse model of peak-ring formation and highlight that this peak ring mainly consists of uplifted granitoids from the mid crust. When brought to the surface during crater formation, these rocks get deformed in a way that dramatically reduces their density and increased their porosity. Downhole logs are rapidly collected, continuous with depth, and measured in situ. They are classically interpreted in terms of stratigraphy, lithology, porosity, fluid content, geochemical composition and structure of the formation drilled. Among the logs collected during Expedition 364, high-quality highresolution acoustic borehole images were acquired. These data can ideally resolve features such as bedding, stratification, fractures, slump folds, and evidence for bioturbation. Because the images are oriented to magnetic north, further analysis can be carried out to provide measurement of the dip and dip direction of planar structures (e.g., a fault) which appear as sinusoids on the image. The amplitude of a sinusoid is proportional to the dip of the plane. The lowest part of the sinusoid indicates the dip direction.

In order to better understand how the rocks weakened and deformed during the impact, we used borehole images to characterize the spatial orientation and vertical distribution of two types of planar features contained in the granitic target rocks of the peakring: (1) dykes (pre-impact or impact-related) and (2) fractures. Pre-impact dyke orientations are tightly clustered. Assuming that these dykes were emplaced under the same stress field (i.e. dike swarms), differential rotation of target rocks appear to have been minimal, suggesting they behaved as a semi-coherent block during crater formation. These results agree with both feather features studies performed at the mineral scale (Poelchau et al., in prep.) and numerical impact simulations (Rae et al., in prep.). Impact related dykes are more variable in orientation than pre-impact dykes, while the impact-related fractures show three well-defined clusters, the origin of which still needs to be determined.

Expedition 364 Scientists: S. Gulick, J.V. Morgan, E. Chenot, G. Christeson, P. Claeys, C. Cockell, M.J.L. Coolen, L. Ferrière, C. Gebhardt, K. Goto, H. Jones, D.A. Kring, J. Lofi, X. Long, C. Lowery, C. Mellett, R. Ocampo-Torres, L. Perez-Cruz, A. Pickersgill, M. Poelchau, A. Rae, C. Rasmussen, M. Rebolledo-Vieyra, U. Riller, H. Sato, J. Smit, S. Tikoo, N. Tomioka, M. Whalen, A. Wittmann, J. Urrutia-Fucugauchi, K.E. Yamaguchi, W. Zylberman.

A NEW MODEL FOR THE FORMATION OF MICROBIAL POLYGONS

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The stratigraphic record of microbially-induced sedimentary structures spans most of the depositional record. Today microbes continue to generate, bind and modify sediments in a vast range of depositional environments. One of the most cited of these settings is the coastal microbial mat system of the Persian/Arabian Gulf. In this setting an extensive zone of microbial polygons has previously been interpreted as resulting from desiccation-related contraction during episodic drying. The objective of this study is to employ 15 years of field-based observations to test the soundness of this model and propose an alternative mode for the generation of the microbial polygons. This new model accounts for the genesis and development of microbial polygons without the need for desiccation-induced shrinkage. Conversely, the production, development and erosion of microbial polygons is a direct result of the overproduction of organic matter in a healthy, yet spatially-limited, microbial community. The recognition of microbial polygons has previously been applied as a diagnostic tool for the reconstruction of ancient depositional environments. The present study calls these interpretations into doubt. It is inferred that preservation of the microbial polygons as a recognisable form is unlikely. Biological degradation and compaction will reduce polygons to produce the 'wispy' laminae that are a common feature of ancient sabkha lithofacies.

INTERACTIONS OF A PALEOCENE RIVER, A RISING FOLD, AND EARLY-DIAGENETIC CONCRETIONS

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Many authors have described syntectonic (growth) strata from fluvial settings. The relative rates of sediment accumulation, erosion, and structural uplift determine whether a growing fold develops positive topographic relief, is beveled by antecedent streams, or is buried under thick growth strata. When folds rise in subsiding basins, upward, convergent flow of groundwater through the permeable growth strata that underlie antecedent streams enhances the flux of ions required for concretion growth. Early diagenetic concretions that grow in such alluvial strata may constitute the only clasts larger than sand size available for transport when antecedent streams become erosive. The first reworked concretions deposited by these streams should accurately mark the transition from aggradation to erosion as folds rise into the paths of streams. In this situation, the ability to differentiate reworked from in situ concretions is crucial.

The west-vergent Simpson Ridge anticline-a N-S trending, thick-skinned Laramide structure in eastcentral Wyoming– separates the larger Hanna Basin (forelimb of the fold, on the west) from the Carbon Basin (backlimb of the fold, on the east). Near the north nose of this anticline, in situ, ironoxide-rich concretions are abundant in folded Paleocene strata (Ferris Formation) and, just to the east, large, reworked, ironrich concretions are abundant in younger, more gently dipping conglomerates in the basal Hanna Formation of the backlimb. Smaller reworked concretions are also present near the base of the Hanna Formation at least 7 km south the anticlinal nose.

At the anticlinal nose, in situ (non-reworked) concretions up to 3 m x 1 m x 1 m are abundant at the top of a ~7 km-thick sequence of sandstones and siltstones that comprise the Late Cretaceous-early Paleocene Ferris Formation. Reworked concretions are absent in the strata hosting these in situ concretions, but reworked concretionary clasts up to 2 m in diameter are present in exposures of conglomerates in the lowermost Hanna Formation that lie just above the in situ Ferris concretions and southeast of the anticlinal nose. These early-diagenetic concretions were originally cemented by siderite ($FeCO_3$). Oxidation of some small, rinded siderite-cemented clasts took place after their fluvial transport into the Hanna Formation, but abundant angular, un-rinded, iron-oxide-cemented clasts indicate that many large, in situ siderite concretions had resided in the vadose zone before they were entrained. The distribution of reworked concretions and the orientations of crossbeds show that antecedent Hanna streams eroded a swath at least 5 km wide across the rising structure. These streams transported Ferris Formation concretions southeastward into the Carbon Basin, and deposited them in a conglomeratic sandstone body now lying within the Hanna Formation. Large calcite-cemented concretions, many with a pipe-like morphology, then grew within Hanna crossbeds. In some cases, these in situ concretions enclose transported, iron-rich concretions, but there is no evidence any calcite-cemented concretions were reworked. The NW-SE alignment of the pipes record southeastward flow of groundwater and thus also provide evidence (together with the orientation of the crossbeds) of the original continuity of the Hanna Formation across the northern third of the exposed anticlinal axis.

MESO-CENOZOIC ACCUMULATION HISTORY OF THE AFRICAN MARGIN OF THE EQUATORIAL ATLANTIC

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The objective of the Transform Source to Sink Project (TS2P) is to link the dynamics of the erosion of the West African Craton to the offshore sedimentary basins of the African margin of the Equatorial Atlantic at geological time scales. This margin, alternating transform and oblique segments from Guinea to Nigeria, shows a strong structural variability in the margin width, continental geology and relief, drainage networks and subsidence/accumulation patterns. We analyzed this system combining onshore geology and geomorphology as well as offshore sub-surface data.

We defined offshore basins stratigraphic architectures of the 3 sub-basins (Sierra Leone /Liberia, Ivory Coast and Ghana / Togo / Benin) and used these to establish their terrigeneous accumulation histories including the whole depositional system (from the shoreline to the most distal deposits onto the oceanic crust). We then corrected these from remaining porosity after compaction as well as in-situ production (mainly carbonates) established from well-data. We included uncertainties related to the time to depth conversion, biostratigraphy, porosity and in-situ production corrections. We discuss our results in terms of Saddler effect for the most recent time periods. Accumulations in the three basins show increased rates during the Cenomanian, Maastrichtian and Oligocene.

We compare these accumulation histories to paleogeographic maps established at the scale of West Africa spanning the continental domain and offshore basins since 200 Ma and discuss their source to sink implications during the opening of Equatorial Atlantic. The Cenomanian accumulation may be related to the erosion of the remaining rift-shoulder following continental break-up. The Maastrichian increase in accumulation could be related to either the tectonic inversion of western Africa at the time or to climatic change affecting erosion capacity in the continental drainage area. The Oligocene peak is contemporaneous of a major drainage reorganization in West Africa following the rise of the Hoggar and the major sea-level fall at the time. Some uncertainties remain to be addressed in the Ghana / Togo / Benin basin on the contribution of the neighboring Niger Delta developing throughout the Neogene as well as the shredding effect of Mass Transport Deposits affecting this segment of the margin.

THE 2.1GA-OLD INJECTITE NETWORK OF THE FRANCEVILLE BASIN, GABON: ARCHITECTURE, ORIGIN AND IMPLICATIONS ON MANGANESE MINERALIZATION

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Detailed sedimentological investigations on numerous outcrops and drill-core sections in the 2.1 Ga-old Franceville basin, Gabon, provide evidence for a large-scale injectite network. The injectites were formed by the injection of sands through a thickness of about 150 m of the FB1 Member, and now cover a minimum area of 70 km^2 corresponding to the Bangombé plateau, but are also recognized close to Franceville 35 km farther south-east. The injectite lithology corresponds to a mud-or carbonate supported sandstone characterized by a loose and uncompacted fabric, without any depositional link with the host-rock. Because the injectites are often parallel to subparallel to the stratification, they were misinterpreted as depositional beds by previous authors. At outcrop, the injectite bodies exhibit sill, dyke, wing and protrusive geometries emplaced during early burial within poorly compacted material, with partial wall erosion and dissociation.

The source of the sand material is attributed to a channel levee turbidite depositional system located in the lower part of the FB1 Member. These deposits were buried by a thick biochemical muddy cap deposited during a starvation phase, which increased the seal capacity of the system. This type of architecture has a high potential to develop compaction disequilibrium during burial. Moreover, in the case of the Francevillian injectites, the abundance of microbial organic matter favoured early methane degassing and lateral charging of the sand reservoir. The overpressure in the channels was periodically released during early burial, through the effect of rapid sedimentary and tectonic loading, and possible seismic activity. The fluidized sand was injected according to a symmetrical wing pattern. Thus, the injected masses caused a local decrease in the grade of the lateritic manganese ore deposit of the Bangombé plateau.

TITAN SEDIMENT MECHANICAL PROPERTIES FROM RADAR AND PENETROMETRY

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The geotechnical properties of planetary surfaces are of critical importance for predicting the interaction of spacecraft with their environment. The design of landing gear (legs, skids, impact attenuators etc.), of mobility systems such as wheels, and of sample acquisition systems (drills, scoops etc.) depend on assumed characteristics of the surface material. Titan is an important target for future solar system exploration, and thus models of the characteristics of its varied terrains are needed.

Although the actual solids at Titan are rather exotic (photochemically-produced organic materials – likely dominated by polycyclic aromatic hydrocarbons (PAHs) and their nitrogen-substituted variants, as well as water ice), and may be moistened with liquid methane and ethane to varying degrees, their overall properties at Titan's low temperature (94K) are not too dissimilar from terrestrial rocks. Thus terrestrial analogs are useful – where remote sensing data such as Cassini's RADAR can identify terrains geomorphologically (e.g. sand dunes, alluvial fans, evaporite plains), terrestrial terrains can guide expectations for their mechanical properties.

There is no substitute, of course, for direct measurement, and the Huygens probe characterized its landing site in some detail. Beyond camera images showing clast size distribution and the striking roundness of the larger clasts, thermal and composition measurements indicated (methane) moisture in the regolith. The impact dynamics of the vehicle as a whole (which landed at 5 m/s on its parachute, penetrating about 15 cm into the ground but then skidding out of the hole) indicate a cohesive but somewhat yielding surface with a resistance of the order of 30 kPa, although the presence of cobbles makes this value somewhat uncertain. The Huygens penetrometer indicated a resistance (of one ~2 cm^2 spot) of 250 kPa. The penetrometer indicated a few mm of soft material, likely dry airfall photochemical dust, lying above a cobble or crust: data from optical instruments also suggest some kind of dust kicked up briefly by the aerodynamic wake of the probe at impact.

These data will be reviewed in the context of a future proposed mission to Titan.

EXPLORATION POTENTIAL OF THE NORTHERN BOLIVIA SUBANDEAN THRUST BELT (BENI BASIN)

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Despite the presence of Late Devonian world-class source rock and several non-commercial discoveries, the northern Bolivian Beni Basin and its associated fold-and-thrust belt is one of the most underexplored Subandean basins in South America. In order to address the petroleum potential of the region, we carried out an integrated study of the tectono-stratigraphic settings of the Northern Bolivian Subandes (NBS).

In this paper, we provide five stratigraphic correlations constructed along and across the Subandean Belt, based on geological maps, stratigraphic sections and wells data. Seven Ordovician to present-day stratigraphic mega-sequences separated by at least six erosive unconformities are detailed and compared from the northern to southern sectors of the NBS. Nine present-day distribution maps of key Paleozoic to Neogene stratigraphic units are also presented and give information related to the subcropping and outcropping extension of the main source rocks, reservoirs, seals and overburden rocks of the basin. Two balanced cross-sections have been constructed.

Results show that Silurian organic-rich formations are only present in the central and southern sectors of the NBS. Distribution area of the main Devonian source-rock has been revised and points out that Devonian strata thin drastically towards the northeast and are absent from part of the external Subandean Zone in the central sector of the NBS. In the northern sector, Devonian section is much thicker and expands in the whole Subandean Zone and towards the foredeep. Carboniferous to Permian units are badly preserved in the external Subandean Zone, especially in the northern sector. However, these units can be very thick in the internal Subandean Zone of the central and southern sectors. Above the main Late Permian to Triassic unconformity that erodes the underlying Paleozoic stratigraphic wedge, lie the eolian to fluvial sandstones of the Beu-Ichoa Jurassic to Cretaceous Formation. Forming the main reservoir of the NBS, these sandstones are widespread despite some variations of thickness. Overlying the main Late Cretaceous unconformity, the Eslabón Formation is also considered as a main reservoir unit which extends through the entire Subandean zone. The Late Cretaceous to Paleocene shallow marine Flora Formation is often considered as a potential source rock and/or regional seal. However, results indicate that the formation is mainly documented in the northern sector of the NBS. Finally, Neogene continental to shallow marine units can be thicker than 5000 m in the external Subandean Zone were they especially accumulated while the Subandean Belt was intensively deforming. They had and still have an important impact on the burial history of the petroleum systems of the Beni Basin.

Tentative sequential restorations of the structural cross-sections are provided and suggest a main Miocene shortening period followed by a Plio-Pleistocene period of vertical uplift of the whole SAZ. Based on both the stratigraphic and structural review of the study area, the potential plays of the Northern Bolivian Subandes are re-evaluated. The main exploration risks are related to the timing and presence of the interpreted structures in depth, but are also influenced by the distribution and quality of the Paleozoic source-rock and Cenozoic seals.

MULTIPLE ISOTOPE ($\delta^{13}C$, $\delta^{18}O$, δ34S AND $^{87}SR/^{86}SR$) RECORDS OF THE EARLY APTIAN OAE1A AND RESERVOIR CHARACTERIZATION IN THE SHUAIBA CARBONATES, RUB' AL-KHALI, SAUDI ARABIA

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Multiple isotopes, including C, O, S and Sr isotopes, were analyzed initially to help correlate the Aptian Shu'aiba carbonates and characterize reservoirs in the eastern Rub' al-Khali, Saudi Arabia at the southern Neo-Tethys margin. These isotopes are very helpful tools for stratigraphic correlation in a field where we have limited biostratigraphic data and heterogeneous depositional facies. These isotopes recorded dramatic climate changes and the oceanic anoxic event (OAE1a) in the eastern Rub'al-Khali. Remarkable negative shifts of $\delta^{13}C$ and $\delta^{18}O$ mark the onset of OAE1a, and the high Sr isotopes and negative shift of $\delta^{13}{}_{org}$ in the early OAE1a indicate a substantial increase of continental input from intensive weathering.

The δ34S profile of sharp positive and negative shifts along with rise and fall of Sr isotopes demonstrates the onset and end of the OAE1a, which may have lasted much longer than 1 Ma. All geochemical data support a slow and gradual change of atmospheric carbon dioxide (CO_2), consistent with a scenario that a long-lasting volcanic CO_2 emission was the cause. The $\delta^{13}C$ and $\delta^{18}O$ shifts of the Aptian stratigraphy are correlated between different fields, and from Saudi Arabia to the Gulf region, Europe, and the Pacific realm. Whereas spatial variations of $\delta^{13}C$ and $\delta^{18}O$ values in the region are a result of change in depositional environments from shelf to slope and basin. The high resolution of $\delta^{13}C$ in the Aptian carbonates reveals four major $\delta^{13}C$ cycles/sequences shifting from positive to negative excursions, and each of these sequence boundaries is marked by a negative $\delta^{18}O$ shift, indicating meteoric water diagenesis in the basin and subaerial exposure in the marginal areas at the sequence boundaries. The four sequences can be further divided into 3rd and 4th order sequences. The different orders of $\delta^{13}C$ sequences are correlated to the different magnitude of sea level change, as they resulted simultaneously from the global climate warming and cooling cycling.

THE FORMATION OF DIAGENETIC BAND RELATED TO FLUID COMPARTMENTS: EVIDENCE FROM THE THIRD MEMBER OF THE EOCENE SHAHEJIE FORMATION INTERVAL, DONGYING DEPRESSION, BOHAI BAY BASIN, CHINA

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Fluid compartments, of which the formation and evolution have important influence on hydrocarbon generation, fluid flow as well as diagenesis in reservoirs, have been recognized as an important component in sedimentary basins. The three-dimensional hydraulic isolation with bounding seals shows periodic pressure evolution process caused by periodic hydrofracture of top seal. Episodic release of pressure related to hydrofracture of top seals act as the main fluid flow mechanism and the important process of material and energy rebalancing in deep part of sedimentary basins.

There is a fluid compartment in Middle and Lower Es3 as well as Upper Es4 intervals with a nonplanar top seal between 2200 m and 3200 m. The top seal mainly distributed in Middle Es3 is affected by faults and structural positions. Previous studies show that there are four major pressure evolution process in the fluid compartment: I Early pressure accumulation period by non-equilibrium compaction (-32.5 Ma); II Early pressure release period (32.5-22.0 Ma); III Later pressure accumulation period by hydrocarbon generation (22.0-10.5 Ma); IV Later pressure release period (10.5-0 Ma). This work shows that the evolution of compartment has important influence on the diagenesis near the top seal.

Clay minerals transformed rapidly near the top seal. Clay minerals in the normal pressure system on the top of top seal changed slowly with I/S up to 80%. It transformed suddenly to 30% with rapidly increasing illite near the top seal. It suggests that clay mineral dehydration is closely related to the fluid compartment while temperature and fluid property changed suddenly through the top seal.

Logging analysis, core and thin section observation revealed an abnormal carbonate cementation band near the top seal. The type and sequence of carbonate cementation were determined by X-ray, thin section and cathodoluminescence observation. Analysis of fluid inclusion and oxygen isotope calculation reveled the formation temperature (time) of each cements. The environmental temperature during calcite, ferrocalcite and ankerite cementation are 75-110°C (32.5-23 Ma), 98-135°C (10-0 Ma) and 110-125°C (7 Ma-0 Ma) respectively. The formation time of calcite cements matches perfectly with the early pressure release period (32.5-22.0 Ma) while the ferrocalcite and ankerite cements formed during the later pressure release period (10.5-0 Ma). The average value of δ^{13}C-PDB of calcite, ferrocalcite and ankerite cements is +2.0‰, +2.1‰ and +2.6‰ respectively. It suggests that the most of the carbon was provided by the carbonate dissolution in shale within the fluid compartment.

The genesis and evolution of fluid compartment may be the key to diagenesis structure of deep sedimentary basins.

LOWER CAMBRIAN THROMBOLITE REEF IN WESTERN MOUNT OF BEIJING

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The microbialite reef consists of three layers in Lower Cambrian Changping Formation, Western Mount of Beijing. They are rubblestone bottomsets, thrombolite foresets, and thrombolite topsets on the core part. In the distal wing, there are some oncolite beds and grainstone.

The thrombolite has well organized clots, mostly rib apperance and parallel to the bed. Their size ranges from 2 to 5 centimeters in outcrops. The reef has been built in two stages at least. Its size is over 10 meters hing and 100 meters wide on the outcrops.

The clots' lithology is micrite dolomite but the matrix is limestone. In the matrix, many bioskeleton detrital can be identified like trilobite etc...

CHARACTERISTICS AND EVOLUTION OF SEDIMENTARY FACIES OF MESO-NEOPROTEROZOIC IN HUAINAN AREA, CHINA

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Since 1960s, primary oil and gas reservoirs of the Meso-Neoproterozoic have been continuously found all over the world, some of which are the commercial oil and gas flows. As a result, the Meso-Neoproterozoic has gradually become a global hot research field. The North China Craton is characterized by thick Meso-Neoproterozoic strata with wide distribution. Located in the southern section of Liao-Lu-Wan Fault Depression Zone on the North China Craton, the study area gets relatively integrated outcroppings of MesoNeoproterozoic strata and relatively strong successive sedimentary sequence, the geotectonic background of which is passive continental margin with the sedimentary environment of Shore-shallow sea environment with north-south gradually deepened seawater. The formations from below to the top are: Jixianian System (Caodian Formation, Wushan Formation, Liulaobei Formation, Sishili Changshan Formation), Qingbaikouan System (Jiuliqiao Formation, Sidingshan Formation, Niyuan Formation, Jiudingshan Formation), Sinian System (Fengtai Formation). According to the detailed measurement and description of the field profiles, the comprehensive research of the lithology, structure, tectonic and their combination features and the analysis of the thin sections, we research the features and evolution of sedimentary facies in the study area. The results appear as shown below. The main sedimentary of Caodian Formation is ferruginous-glutenite with well-rounded but poor sorting, scouring surface being found at the bottom. The depositional environment of Caodian Formation is coastal calcirudytic. The contact relationship between Wushan Formation and Caodian Formation is parallel unconformity with visible weathering crust on the contact area. The main sedimentary of Wushan Formation is fine grain quartz sandstone with low-angle cross-beding, parallel bedding, flushing cross-bedding, ripple mark developing, its depositional environment is fore-shore. The main sedimentaries of Liulaobei Formation are purplish red-celadon marl and celadon shale brow brown-yellow dolomite with orizontal bedding found. The depositional environment is neritic shelf. The depositional environment in lower part of the Sishili Changshan Formation is also foreshore but upper part is shore face with the main sedimentaries of fine sandstone, siltstone and shale. After that, the seawater become more shallowing and clearer, and the depositional environment of overlying stratas below Jiuliqiao Formation is carbonate tidal flat and the main sedimentaries are mud-sized crystalline dolostone, crystal powder dolomite, argillaceous dolomite and so on. In Jiuliqiao Formation stromatolite reef and partial siliceous bands can be found with mingled storm rocks. The depositional environment is subtidal zone. In Sidingshan Formation, Horizontal laminated bed develops. The depositional environment is supralittoral zone. In Niyuan Formation massive stromatolite, ripple mark and abundant microbially induced sedimentary structure develops. The depositional environment is intertidal zone. In the bottom of Jiudingshan Formation, the main sedimentaries are edgewise dolomite and dolarenite and the depositional environment is subtidal zone. The main sediment aries of Fengtai Formation are fuchsia pebbled sandstone and dolomitic conglomerate with poor sorting gravel. The depositional environment of Fengtai Formation is glacial deposit. In accordance with comprehensive analysis, in the study area, the seawater of Meso-Neoproterozoic went through a shallowdeepshallow cycle, and the main sediment environment is barrierless coast neritic shelf carbonate platform.

STRUCTURE CONTROLLING EFFECT ON SEDIMENT SYSTEM AND ITS SIGNIFICANCE TO OIL EXPLORATION IN NORTH OF DONGPU DEPRESSION

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Sediment assemblage of a continental faulted basin is mainly controlled by the variation of the accommodation space and the sediment system. The variation of the accommodation space of an extensional faulted basin is mainly influenced by the activity intensity and the distribution style of the dominate fault. Palaeogeomorphology is the key factor of the originating and the distribution of a sediment system. It dominates the region of provenance, the main palaeocurrent direction, and the sandbody distribution. The matching styles between contemporaneous faults and sediment systems control the types of sandbody.

Under the control of a series of main contemporaneous faults (Weicheng fault, Chenying fault, Mazhai fault, etc.), numbers of positive and negative structural units with trending of NNE were formed in S3FM. in north part of Dongpu depression. The provenance orientation is influenced by the intersection styles of faults, the thickness and distribution of sand are influenced by the intensity of fault activity and the gradient of ground relief.

Materials form the provenance in this area was transported to the lake with an oblique orientation. In the case of a large angle between the fault trending and the provenance orientation, it’s common to form thick turbidite sandbody in the footwall. Compared with the sandbody in the hanging wall, the turbidite sandbody is thicker and the thickness is variable, and the distribution area is smaller. In the other case of a small angle between the fault trending and the provenance orientation, it tends to form a thick ellipse sandbody along the axes of the fault trough in the footwall. Based on the matching styles of different fault styles and sediment system, 6 models of “structural-controlled sandbody” have been established.

According to the models of “structure-controlled sandbody”, the up-dip structural belt and the turbidite sanddody are favorate areas in which we detect the lithology and structure-lithology reservoirs. Field practice has made great achievement in the trough in Dongpu depression.

RESEARCH ON CHARACTERISTICS AND CONTROLLING FACTORS OF THE SUBSALT DOLOMITE OF MAJIAGOU FORMATION IN NORTHERN SHANXI AREA, ORDOS BASIN, CHINA

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Dolomite reservoir plays an important role in the study of carbonate rocks and oil-gas exploration. Recently, there are many progresses in dolomite with the strong demand of petroleum exploration, especially in the study of Ordovician dolomite in Ordos Basin which has been an important area of exploration with continuous research and exploration.

The paper systematic analyses the characteristics of the subsalt dolomite of Majiagou Formation in northern Shanxi area of Ordos Basin through core observation, cast slice, scanning electron microscopy, electron probe, laser confocal microscopy, constant pressure Hg experiment, constant-rate mercury injection, reservoir property analysis and carbon/oxygen isotope analysis, the controlling factors are deeply approached.

There are various types of reservoirs with good quality in the 7th and 9th submembers of the 5th member (Om5) of Ordovician Majiagou Formation which are the main stratas of the gas exploration in the Ordovician Subsalt layer. Reservoir rock mainly consist of powder-fine crystal dolomite with argillaceous powder crystal dolomite which shows obvious cyclicity on the vertical. The types of reservoir are extremely abundant which include intergranular pore, intragranular pore, intercrystalline pore, intercrystalline solution pore, solution pore, gypsum mould pore and micro fractures, and the majority are intercrystalline pore and solution pore. The pore structure is characterized by the relatively coarse pore throat and fair well sorted. The main distribution of porosity between 2%~10%, 5.02% on average. The permeability mainly distributes between 0.01 mD~10 mD, 0.65 mD on average. The result shows that the reservoirs belong to extra-lowporosity and low-permeability one.

The stratabound property, facies-controlled property and TSR reaction control action of subsalt dolomite reservoir in study area give a strong basis for subsalt reservoir prediction. The study provides the following views:

(1) The forming environment of dolomitization is controlled by sedimentary facies. Grain shoal microfacies and microbial reefs microfacies are favorable facies belts for the subsalt dolomite reservoir and lime dolomitic flats, plaster dolomitic flat and gypsum-bearing dolomitic flat come second.

(2) Sedimentary sequence determines dolomitisation. It was transgression stage when 7th and 9th submembers of the 5th Member (Om5) developed, which mainly consist of pure carbonate rock and a little gypsum dissolving can be seen locally. Blend water dolomitization developed in later period which was characterized by the development of intercrystalline pore-dolomite reservoir.

(3) Frequent oscillation of the seawater was favorable for the first stage of subsalt reservoir dissolving. The TSR reaction provided advantages for the second dissolution of subsalt reservoir buried.

TYPES AND CHARACTERISTICS OF LAKE DEEP-WATER GRAVITY FLOW HYBRID EVENT BEDS OF CHANG 7 FORMATION IN ORDOS BASIN, CHINA

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The debris flow and turbidity current are mainly existed in the deep-water gravity flow, there is a mutual transformation between them, however, which make a single gravity flow event form multiple types of mixed gravity flow deposition combination, resulting in its distribution is more complex. Hybrid event bed refers to the deposit of mixed deep-water gravity flow in a single gravity flow event which contains turbidity current, debris flow and sometimes transitional flow. In recent years, with the development of the Integrated Ocean Drilling Program (IODP) and the extensive use of the Light Detection And Ranging (LIDAR) in digital outcrops and cores, making fine correlation of deep-water cores and meticulous depiction of field outcrops become possible, but also contributed to the discovery and research of deep-water gravity flow hybrid event beds. The study on the depositional characteristics and distribution of the hybrid event beds is of great significance to enrich and perfect the theory of deep-water gravity flow deposition and to carry out the oil and gas exploration and development of the deep-water gravity flow sedimentary sand bodies. The gravity flow sedimentation theory, which is represented by the continental lake basin of Chang 7 in the Triassic Yanchang Formation of Ordos Basin, has achieved good results in oil and gas exploration. This paper uses geology, deep-water sedimentology, based on the anatomy of the key outcrops and cores, and then combining with well logging and analytical data, thoroughly study the types and distribution characteristics of deep-water gravity flow hybrid event beds of Chang 7 Formation in Eastern Gansu, Ordos Basin. Research shows that Chang 7 mainly subdivided into three types: sandy debrite-turbidite couplets (type I), co-genetic turbidite-muddy debrite beds (include co-genetic turbidite-muddy debrite beds with rich mud clasts (type II1) and co-genetic turbidite-muddy debrite beds with poor mud clasts (type II2), and turbidite muddy debrite multi-interplayered beds (type III).Type I and type II1 hybrid event beds are distributed from proximal and distal of deep-water gravity flow depositional district, type II2 and type III hybrid event beds are mainly distributed from distal. On the whole, deep-water gravity flow system in study area Chang 7 Formation has ribbon distribution and obvious channelized characteristic at proximal, adjacent lobes sediment overlap and connect each other with ring-ribbon distribution at distal, it is channel type (non-sectorial) gravity flow depositional system. It has a great guiding significance to study the characteristics and distribution of deep-water gravity flow hybrid event beds of Chang 7 Formation in Eastern Gansu.

THE STEPWISE SEDIMENTARY MODEL OF THE DEEP-WATER MULTI-STEP SLOPE IN THE PASSIVE CONTINENTAL MARGIN (SOUTH CHINA SEA)

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Deepwater slope processes play a very significant role in the sediment transport from neritic shelf into the abyssal basin. This study uses the seismic sedimentological methods to study and analyse the deepwater slope systems. The results reveal that shelf slope has multiple steps and show stepwise transport of the sediments. The first-step slope is characterized by canyon groups, while the second-step slope is distinguished by large canyon complex. All the different-step slopes show strengthening at the upper part and weakening in the lower part in erosion, which results in sediment passing in the upper slope and sedimentation in the lower slope. Sediment accumulation in the first-step slope makes it to be the sediment source of the second-step slope, showing a stepwise sedimentary model. This multisteps of the shelf slope and its stepwise sedimentary model are controlled by both tectonic activities and sediment input, as well as by sealevel changes. This model reveal the micro-distribution rules of the slope sedimentary processes and it has implications to guide deepwater hydrocarbon explorations and submarine engineering constructions.

AN OLD REMNANT CARBONATE PLATFORM MARGIN IN TARIM BASIN, NORTHWEST CHINA: ITS GEOLOGICAL MODEL AND CONTROL ON RESERVOIR

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Carbonate platform margin is a very important field for oil and gas exploration. The type of carbonate platform margin controls reservoir formation and petroleum production. The platform margin of Lianglitage Formation (Lianglitage platform margin), Upper Ordovician is an important oil/gas bearing place in Tabei area, Tarim basin, Northwest China. With the increasing degree of oil/gas exploration in Tabei area, it becomes very urgent to carry out fine description on the Lianglitage platform margin.

Data and Methods: 3D seismic data of 5000 km^2 and 46 drilling holes are used in this paper. Sedimentary facies is studied based on core observation and thin section identification. The distribution of Lianglitage platform margin is depicted by stratigraphic thickness interpretation and seismic facies analysis in the study area. After that, the control effect of margin type on reservoir development and oil and gas production is analyzed.

The results include:

(1) It mainly develops open platform, platform margin, slope facies and basin facies in Lianglitage Formation in Tabei area. The Lianglitage platform is denuded and wedged out to the north. The residual strata are mainly platform margin facies.

(2) Four kinds of seismic facies can be identified in Lianglitage platform. Wedge seismic facies with high-amplitude and mound seismic facies with middle-high amplitude is the response of platform margin.

(3) The Lianglitage platform margin, which is about 240 Km long from east to west, 10-20 Km wide from north to south and an area of about 2600 km^2, is banded near EW surrounding the Tabei palaeo-uplift.

(4) The Lianglitage platform margin has segmentation on the east-west direction. The western part located in YingmailiHalahatang – Tuoputai area is weak rimmed carbonate platform margin with steep margin slope. High energy platform margin reef beach facies is developed in this part. The eastern part located in the Tahedong area-Lungudong area is ramp type carbonate platform margin with wide and gentle margin slope. Middle-high energy platform margin reef beach facies is developed in this part.

(5) The segmentation of the Lianglitage platform margin resultes in the difference of the reservoirs, and then affects the differences of oil and gas production in these two parts. The reservoir in the western part is of good quality, thick, and large lateral variation. The reservoir in the eastern part is of poor quality, thin, and wide distribution. The segmentation of Lianglitage platform margin has important guiding significance for selecting favorable exploration area in Tabei area in the future.

DIAGENETIC HISTORY AND RESERVOIR QUALITY OF TIGHT SANDSTONES: A CASE STUDY FROM THE UPPER PERMIAN SHIQIANFENG FORMATION IN DONGPU DEPRESSION, BOHAI BAY BASIN, EASTERN CHINA

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The upper Permian Shiqianfeng tight sandstone, located in Dongpu Depression, Bohai Bay Basin, China, is composed of fluvio-lacustrine sediments and is rich in volcanic dust. This study focuses on diagenetic processes and reservoir quality of the Shiqianfeng tight sandstone on the basis of different lithofacies. This study used an integrated approach, such as core observation, point-count analysis of thin sections, X-ray diffraction (XRD), scanning electron microscopy (SEM), cathode luminescence (CL), electron microprobe analysis (EMPA), and stable isotope analysis of carbon and oxygen compositions, and fluid inclusion analysis. The tight sandstone reservoir mainly consists of subarkose and lithic subarkose material, with high contents of volcanic dust (average 7.93%), and has undergone significant diagenetic events, including compaction, quartz cementation, carbonate cementation (mainly calcite and ferrocalcite), development of chlorite rims, and precipitation of kaolinite and mixed illite/smectite (I/S) layers. During the burial history, the volcanic dust became altered, resulting in the production of abundant silicic materials and depletion of metallic ions (i.e., Fe^{2+}, Mg^{2+}, Ca^{2+} and Mn^{2+}). This process formed subhedral micro-quartz, pore-filling authigenic quartz, smectite and chlorite rims during the early diagenetic stage. Calcite/ferrocalcite cementation occurred in several samples and was also influenced by volcanic dust alteration, resulting in high contents of Mn^{2+} (average 12.5 mol %). Further alteration of volcanic dust occurred during the mesogenetic stage, and kaolinite cement, euhedral micro-quartz and intercrystalline pores are developed. Partial to complete syntaxial quartz overgrowth developed as a result of smectite-to-illite reactions and the alteration of volcanic dust. Late-phase carbonate cements (dolomite and ankerite) are rare. The present tight reservoir of the Shiqianfeng sandstone with low porosity (average 6.17%) and permeability (average 0.198 mD) mainly resulted from intense compaction, diverse cementation and the presence of volcanic dust. The modification of reservoir quality by volcanic dust alteration is limited.

FORMATION PROCESSES OF CHLORITE RIMS AND IMPACT OF PORE-LINING CHLORITE ON RESERVOIR QUALITY: A CASE STUDY FROM SHIQIANFENG SANDSTONES IN UPPER PERMIAN OF DONGPU DEPRESSION, BOHAI BAY BASIN, EASTERN CHINA

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The source material, precursor and formation processes of chlorite rims, and impact of pore-lining chlorite on reservoir quality of the Shiqianfeng sandstones, Dongpu Depression, Bohai Bay Basin, China, has been discussed in this study. An integrated approach, including core observation, point-count analysis of thin sections, scanning electron microscopy, electron microprobe analysis and cathode luminescence were utilized. On the basis of sedimentary facies and particle size, four lithofacies identified in Shiqianfeng fluvio-lacustrine sandstones. The petrographic analysis shows that chlorite rims consist of grain-coating chlorite, poor-crystallized pore-lining chlorite and euhedral-crystallized pore-lining chlorite. Chemical composition show that pore-lining chlorite is mainly Fe-rich with an average of 0.785 for Fe/(Fe+Mg) ratio. Meanwhile, the Shiqianfeng sandstones have a large content of volcanic dust (3.0%~16.0%, average of 7.93%). Alteration of volcanic dust, which provides sufficient Fe^{2+} and Mg^{2+}, has close relevance with poor-crystallized pore-lining chlorite. Transformation of volcanic dust to smectite rims started with shallow burial depth at early diagenetic stage, and smectite rims altered to poor-crystallized chlorite rims in situ. Euhedral-crystallized chlorite mainly develops in sandstones with high porosity, high permeability and open flow system. Despite pore-lining chlorite can inhibit quartz overgrowth, it cannot effectively stop pore-filling authigenic quartz, carbonate and kaolinite cements, suggesting that pore-lining chlorite cannot protect porosity from being destroyed. Contrarily, occurrence of pore-lining chlorite is a barometer of good reservoir quality and intense hydrodynamic conditions.

DEEP WATER SEDIMENTATION IN THE BARREIRINHAS BASIN, NE BRAZIL: EXAMPLES FROM 3D SEISMIC DATA

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The Barreirinhas basin is one of the several sedimentary basins along the equatorial margin in NE Brazil formed by the opening of the Atlantic Ocean. The sedimentary fill is essentially Cretaceous and Cenozoic in age which, in its distal parts, is in excess of 9 km. The modern shelf break corresponds to a long lasting prominent bathymetric feature – at least since the Late Cretaceouswhich separates the shallow and deep parts of the basin. The current interpretation is that this feature corresponds to the continental-oceanic boundary or an abrupt transition between normal and thinned continental crust. In the deeper parts of the basin the syn-rift sedimentary pile is relatively thin and restricted to poorly imaged grabens. The stratigraphy of the deeper parts of the basin is still poorly understood due to the few wells drilled (reaching only the uppermost Turonian) and the significant differences between shallow and deep water stratigraphy. The published lithostragraphy for the deep water part of the basin is rather simple, with mud-dominated Travosas and Pirabas Formations ranging from Late Cretaceous to Recent sediments. Although the stratigraphy is not fully understood, the sedimentation rates are very high, over 100 m/Ma during the Late Cretaceous and up to 80 m/Ma during parts of the Cenozoic.

Recently acquired deep water 3D seismic allow the observation of different sedimentary packages, each composed of well-defined sedimentary features. One of the most striking intervals is a laterally extensive MTD averaging 800 m thickness (locally more than 1000 m thick) and other thinner and more restricted MTDs at different stratigraphic levels.

The Santonian interval characteristically has highly sinuous, thin channels with minor levee development. Locally overbank lobes are observed. The sediment transport direction is quite varied between channels and within the same channel system, commonly with over 90° variability. This is interpreted as a consequence of a gently dipping sea floor with no tectonic influence and only locally influenced by previous channel systems that formed positive reliefs.

Higher in the sequence the Campanian-Maastrichtian interval is dominated by large (up to tenths of kilometers across) terminal lobes (likely sandprone) frequently overlain by leveed meandering channels. The common association of these two suggests Early lowstand (lobes) and Late lowstand (channels) as the dominant stages of sedimentation during this time interval. The sediment transport direction is much more restricted, rarely departing from the same quadrant (< 45° variability)

The Tertiary section comprises large (up to 1000 m thick, 20 km wide) layered, mound-like features tentatively interpreted as contournites which are in turn cut by a series of channel systems that have the same overall direction as the Maastrichtian channels and lobes.

SPATIAL VARIABILITY OF SURFACE SEDIMENTS GRAIN-SIZE OF THE LOIRE ESTUARY

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Three hundred thirty Van Veen grab samples were collected from surface sediments along the Loire estuary, from the upstream of Nantes to the estuary mouth (80 km long). The main objective of this work is to study the spatial distributional patterns of grain size characteristics and their link to environmental parameters (e.g., transport processes, hydrodynamics, sediment sources, etc).

Grain size analyses were performed with a laser granulometer Mastersizer 3000 Malvern and the Gradistat© package was used to calculate grain size distribution and statistics parameters. Maps present the spatial distribution of the major parameters describing the shape of distribution (mean, sorting, and skewness) and the stream power. An analysis of the prominent peaks (modality) was also performed to identify the sedimentary signature of the different sediments sources and transport processes.

The results show that the trend of the median grain size in the central part of the channel reflects the non-linear evolution of stream power along the estuary continuum caused by the opposing forcing of tide currents and river discharge. Out of the boat channel, on the estuary subtidal shoal, the skewness values characterize the tidal deposits which indicate bed-load transport by bidirectional tidal currents, alternating deposition from bed load and suspended load, tidal scour, and regular fluctuations of tidal current velocity. In contrast, deposits indicative of swell (oscillating waves, and storms) are much less conspicuous. Because of the abundance of shell debris on the lateral mudflats, decarbonation was necessary before grain-size measurements to perceive the enrichment in fine particles associated with the maximum turbidity zone and the vessel-generated wave.

EVALUATION OF TWO NEAR SURFACE GEOPHYSICAL METHODS TO INVESTIGATE MUD FLAT DEPOSITS IN THE LOIRE ESTUARY

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The efficiency of DC-electrical resistivity measurement and seismic response (multichannel analysis of surface waves –MASWand refraction –impact hammer-) was tested in mudflat environments (mud, sand, brackishwater). The perspectives were of three types: (1) sedimentological to describe the spatial variability of the estuarine mud flats architecture, which is too shallow to be investigated with the usual onboard geophysical tools, (2) geochemical to follow fluid (gas / water) circulations in the sediment and (3) methodological to implement terrestrial techniques on a difficult accessibility foreshore.

The test site is a mudflat area on the left bank of the middle estuary of the Loire River. This station is already known thanks to a forage/borehole drilling database (Sub-Soil Database from BRGM). These two geophysical methods were carried out on the upper mudflat (thickness sediment ~ 6 m, altered rock ~ 2 m then bedrock), and on the mid-mudflat (thickness sediment ~ 12 m).

Electrical resistivity results: The upper mudflat electrical resistivity tomography (ERT) is 96 m long and 18 m depth. The resistivity is low in this water and salt saturated environment, but sufficiently contrasting to show three compartments whose thicknesses are in accordance with the drilling information. The resistivity is fairly constant and < 4 Ω.m in the upper 6 m of mud, varies rapidly between 4 and 11 Ω.m into the 2 m of altered rock, and reaches ~ 15 Ω.m into the bedrock (gneiss). The mid-mudflat ERT confirms these data but since it was impossible to install a long cable on this mudflat due to walking access difficulties, the depth of investigation is weaker and does not reach the bedrock to validate the rock resistivity value obtained on the upper mudflat.

Seismic results: As the mud is water and gas saturated, the density of the medium is inputted as floating parameter to allow its evolution during the inversion model adjustment. The latter is also constrained by ERT results in order to reduce the number of tested models. Seismic signal recording on the upper mudflat shows a constant P-wave propagation velocity in the first 6 meters of sediment (~300 m.s-1), then a sharp threshold (6.5 m) and a new propagation velocity at 2000 m.s-1. Thus, this tool performs good measurements but does not seem relevant because it is dependent on the knowledge acquired with the ERT and gives information only in vertical 1D.

After all, the electrical resistivity has been chosen to perform further tests. Because of the access difficulties on the mudflat, new tests will be conducted in September 2017 by sea-surface electrical streamer and aerial electrical streamer towed by a hovercraft. Some tests will also be carried out to estimate the ability of the method to detect fluid content changes and thus fluid flows in the sediment during a tidal cycle (timelapse measurements).

CARBONIFEROUS CARBONATE PLATFORMS AND CORAL-REEFS IN SOUTHERN CHINA

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The Carboniferous was a critical period in Earth's history with the Gondwana superglaciation and significant continental collisions linked to the assembly of the Pangaea. These changes induced drastic climatic changes, high-frequency sea-level fluctuations and influenced the evolution of reefs. Currently, the Carboniferous is considered as a period of global recession in reef building following the Frasnian/Fammenian (F/F) extinction event. Shallow-water coralliferous bioconstructions were overall small and scarce and corals played a minor role in their construction. However, in Southern China, newly discovered Pennsylvanian coral reefs challenge the impact of the F/F extinction event on the reef evolution.

The project focuses on these exceptional Pennsylvanian coral-reefs discovered in the Guangxi province (South China). During the Carboniferous, the area was an epicontinental sea located at a subequatorial–equatorial position, near the eastern border of the Paleo-Tethys Ocean. Sedimentation occurred in the passive continental margin of a craton, in the Dian-Qian-Gui basin, recording near shore siliciclastic and carbonate platform facies.

In order to constrain this conspicuous occurrence of Pennsylvanian coral reefs, the paleoenvironments were reconstructed using stratigraphic sections and microfacies analysis. The first section measured consists of amalgamated limestones ranging in age from Late Devonian to Early Permian and located at the platform margin, close to the coral-reef outcrops. The field aspects, the internal sequences and the microfacies features indicate transport and redeposition of sediments driven by turbidity currents, exporting materials from platform top to slope environments. Thus, the wackestone, packstone and grainstone beds correspond to calciturbidites and mudstone corresponds to background sediments.

The sedimentary record of the platform, located in a tectonically stable passive margin, is conceived as a response to sea-level fluctuations. These variations controlled the input and the composition of calciturbidites. The Microfacies Types composed of grainstones and dominated by shallow-marine bioclasts, peloids and coated grains (oncoid grainstone, lithoclastic breccia and coated bioclast packstone to grainstone), deriving from platform margin, reflect shallow-water conditions on the platform-top. The Microfacies Types dominated by wackestone and packstone, devoid of encrusted grains but rich in skeletal grains (skeletal grain packstone to wackestone, crinoid packstone to grainstone) deriving from platform-top, reflect a highstand in sea level. Finally, the deposition of mudstone layers reflects period of low carbonate input into the basin and quiet-water sedimentation. A general trend emerges from relative sea-level variations and is globally consistent with eustatic sea-level fluctuations.

Further research planned include geochemical analyses, specifically carbon and oxygen isotopes, using brachiopod shells and marine cements with the goal to constrain sea-water composition and paleoclimate. The studied section allows to constrain environmental factors and reconstruct the sedimentological dynamic of the carbonate platform margin, poorly understood yet, in order to explain these exceptional Pennsylvanian coral-reef discoveries and evaluate the implications on the current knowledge of the F/F extinction event.

DOLOMITIZATION AND DEDOLOMITIZATION OF THE UPPER JURASSIC CARBONATE ROCKS IN THE GENEVA BASIN (SWITZERLAND AND FRANCE)

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The Canton of Geneva (Switzerland) is currently exploring the opportunities for geothermal energy exploitation in the Geneva Basin (GB) sub-surface. In this context, a structural analysis of the basin associated with reservoir appraisal and rock-typing of reservoir bodies of potential interest were conducted. Diagenesis of carbonate rocks is known to affect the petrophysical properties of the host rock. Assessing the diagenetic history is thus essential when evaluating any reservoir exploitation project.

Horizons affected by dolomitization, the focus of the present study, are of particular interest because they proved to be productive in time-equivalent deposits currently exploited in Southern Germany and are suitable for geothermal energy production. The Upper Jurassic carbonate rocks of the GB (the Calcaires Récifaux, Calcaires de Tabalcon and Calcaires de Landaize Units) represent the best potential reservoirs. However, these units exhibit strong heterogeneities in terms of reservoir quality with the occurrence of highly porous dolomitic intervals in the western part of the basin, becoming tighter to the south-east. Three study sites where the Upper Jurassic carbonates outcrop were selected at the surroundings of the GB: the Jura Mountains (north-western), the Vuache Mountains (south-western) and Salève Mountains (south-eastern). In addition, one core close to the prospected area was studied (Humilly-2 borehole).

The detailed study in each site focused on (1) the petrographical analyses in order to assess texture, fabrics, types and distribution of porosity and (2) to constrain the paragenesis for each stratigraphic unit prior to discussing the cause and effects of dolomitization.

Most of the initial porosity in the different units studied was filled through several stages of blocky calcite cementation during early burial diagenesis. Almost all units exhibit two stages of blocky cementation while the Calcaires Récifaux showed a third, incomplete, stage of blocky cementation with preservation of some intracrystalline macroporosity. Dolomitization is mainly represented by planar, non-mimicking replacement dolomite, overprinting previous diagenetic stages. The *Calcaires de Tabalcon* and the *Calcaires Récifaux* are the most affected units. The detailed petrographic study showed that the dolomite rhombs are characterized by cloudy cores followed by limpid rims indicating that the cores developed in precursors originally consisting of low-Mg calcite while the rims precipitated from solutions under-saturated in regards to low-Mg calcite. This is consistent with previously published reflux type model of dolomitization. Dedolomitization is observed at different order of magnitude by either: (1) an almost complete dissolution leading to the creation of secondary pore space or (2) a two-step calcitization driven by the infiltration of Ca-rich water leading to dissolution, formation of microvugs and then precipitation of calcite.

The study presented here will help to understand the possible models of dolomitization that occurred in the GB and to provide insights into porosity and permeability distribution that will ultimately help in reservoir modeling, a crucial step for further potential exploitation.

DIAGENETIC ORGANIC MATTER ANC CLAY STUDIES TO PRECISE THE GEODYNAMIC HISTORY AND HYDROCARBON MIGRATION SYSTEM OF THE HIKURANGI PRISM (NORTH ISLAND, NEW ZEALAND)

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The Hikurangi prism (HiPr) has undergone several deformation episodes periods mainly related to subduction processes, and leading to complex stratigraphic and structural patterns: i) Initial formation of an accretionary complex on the eastern Gondwana margin during Triassic, Jurassic, and early Cretaceous times; ii) a stage of tectonic quiescence state during Late Cretaceous to Oligocene times; iii) and the renewal of westward subduction beneath North Island since the Early Miocene to present day. The onland exposure of the Neogene trench slope basins together with their Jurassic to late Paleogene pre-subduction series permits to provide a high-resolution sampling grid including all lithostratigraphic units. It allows also the study of origin and spatial distribution of organic matter (OM) and clay minerals through time. This study, which is mainly based on onshore sampling, could also be extended to neighbouring offshore areas. There, cutting analyses from two prospecting oil wells Titihaoa-1 and Tawatawa-1 are included. A multi–proxy approach was performed to determine organic matter (OM) maturity (organic petrography, Rock-Eval pyrolysis, vitrinite (VR) and solid bitumen reflectance (BR) %) compared with clay mineral reaction progress (illite Kübler-Index (KI) and clay mineral paragenesis). Due to the lack of non-marine intervals in the HiPr, thus a rare occurrence of vitrinite, OM studies have produced controversial and uncertain results in the last two decades. The combination of clay mineral indices and OM reflectances and specifically the VR versus BR comparison enables the recognition of heat flow changes during sedimentary and tectonic burial. Determining different bitumen populations and thus hydrocarbon migration allows a better understanding of the thermal evolution and fluid migration system. VR and Rock-Eval pyrolysis results show a homogeneous maturity pattern in the thick Neogene sedimentary cover. These measurements reflect a very low geothermal gradient through the Early Miocene to Late Miocene within the HiPr. Illite/smectite interstratifications in the Miocene strata but also in the Late Cretaceous, and even in the deepest structural levels, are consistent with the low burial temperature gradient evidenced by Rock-Eval and VR results. However, an increase in VR in Jurassic to Early Cretaceous rocks shows higher geothermal conditions. After deposition during the Jurassic to Early Cretaceous, the oldest rocks of HiPr were deformed in the accretionary wedge. From ~100 Ma, the thermal history preserved in the Jurassic rocks and again recognized after a sedimentary hiatus in the Early Cretaceous rocks implies that this region was very stable until the Late Oligocene. Exhumation by accretion at the prism front prevented reheating and a typical moderate geothermal gradient was established, thus preventing hydrocarbon production. When subduction started around ~25 Ma the geothermal gradient decreased to a lower geothermal gradient as present day. However due to burial increment during Early to Late Miocene a hydrocarbon migration system started. At least three periods of fluids migration can be distinguished between Early Miocene to Pliocene. These are associated to bitumen migration (solid bitumen) and gas hydrate formation related to main deformational events and can be linked to the Late Cretaceous to Paleocene source rocks of the basin.

SOLID BITUMEN IN MIOCENE TUBULAR CARBONATE CONCRETIONS: IMPLICATIONS FOR HYDROCARBON MIGRATIONS AND PALEO COLD SEEP SYSTEMS IN THE HIKURANGI PRISM (NORTH ISLAND, NEW ZEALAND)

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On the Hikurangi prism (HiPr), the analysis of offshore seismic lines suggests that a strong relationship exists between tectonic structures and fluid migrations. Paleo-methane seeps are also reported onshore in Miocene rocks and indicating that hydrocarbon expulsion and migration occurred on the margin since 25 My. Previous work on tubular carbonate concretions, outcropping in the uplifted onshore HiPr, has demonstrated that they correspond to the shallow subsurface plumbing systems of paleo cold seeps. In the Akitio syncline, east of Pongaroa, Early to Middle Miocene syn-subduction mudrocks are exposed. These outcrops display tubular carbonate concretions that formed in a Miocene trench slope basin. The tubular carbonate concretions in Lower Miocene mudrocks, occured along a N-S trend, while in middle Miocene strata, they occur along NNE-SSW trends. The N-S trend parallels a major fault zone, the Breakdown Fault Zone, which separates two wide synclines, the Waihoki and Akitio synclines oriented NNE-SSW as the tubular concretions in Middle Miocene rocks. Our mapping and tectonic analysis therefore suggest that a strong relationship exists between the main structural directions and the occurrence of tubular concretions. New petrographic observations of the Middle Miocene paleo-plumbing system show for the first time the presence of migrated solid bitumen within the tubular carbonate concretions, also found in the Breakdown FZ. A multi–proxy approach was performed in source rocks, faults, tubular carbonate concretions and their host rocks to determine organic matter maturity (organic petrography, Rock-Eval pyrolysis, vitrinite (VR) and solid bitumen reflectance (BR) %) and clay mineral reaction progress (illite Kübler-Index (KI) and clay mineral paragenesis). In the Middle Miocene, low Tmax values < 435°C from Rock-Eval data indicate a thermally immature system which has not passed the oil window as indicated by VR Rr% (Rr: random reflectance) value of 0.68 Vr[%]. The Kübler Index measured on two different clay size fractions (< 2 µm and < 16 µm) are generally similar (+/-0.08) suggesting that < 2 µm clay minerals do not registered the very low PT conditions of Middle Miocene rocks but the PT conditions of detrital micas. However, vitrinite reflectance in the main source rock of the HiPr (Waipawa Black Shale) indicates that these rocks are mature (VR = 0.8 – 0.9 Rr%) and have produced hydrocarbons. The analysis of solid bitumen in the Breakdown Fault Zone shows a lower maturity (BR = 0.6 – 0.8 Rr%) than the maturity of the source rocks. Solid bitumen in the tubular carbonate concretions shows that all homogeneous type solid bitumen exhibit low reflectivity and no bireflectance due to low maturity. Solid bitumen is not randomly distributed within the tubes and occur between cementation phases often associated with framboidal pyrite. It has a mean random reflectance of BR = 0.78 Rr% with low standard deviation. This provide evidence of at least one previously unproven petroleum migration event in the HiPr during Middle Miocene time. Tubular concretions during that time were used as a migration pathway for deeper thermogenic hydrocarbons and not only for biogenic shallow methane.

LAST DEGLACIAL SEDIMENTARY RECORD ALONG THE MIXED CARBONATE-SILICICLASTIC MODERN SHELF EDGE IN THE GULF OF PAPUA: RESPONSE TO SEA-LEVEL RISE AND CLIMATE CHANGES

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We present a sedimentary record of the last deglaciation from the mixed carbonate-siliciclastic coastal environment currently drowned along the shelf edge in the Gulf of Papua. Our study is based on an 8.5 m-long piston core (MV26-0403-73JPC) retrieved at a water depth of 112.6 mbsl (-9.783 S, 144.417 E) and located less than two kilometers from the shelf edge, in a gap between a 50 km-long linear ridge, interpreted to be an early deglacial drowned barrier reef.

Four main units, A to D, are identified based upon sedimentological, mineralogical, and paleontological variations up the core. The lowermost Unit A is dominantly carbonate with gravel-to-sand grain size. Grain types are high-Mg calcite ooids, Halimeda plates, peloids, coral fragments, gastropods, and larger benthic foraminifers such as Calcarina spp. A ^{14}C date at the base of unit A indicates an age of 17,040 (±347) cal yrs BP. The overlying Unit B is sandy and marked at its base by an abrupt increase in siliciclastics and the first occurrence of wood debris. The overlying unit C records major changes such as the appearance of planktonic foraminifers, a shift in the benthic foraminiferal assemblage with Amphistegina spp. (e.g. A. radiata, A. bicirculata) becoming the dominant species, and a lack of ooids and wood debris. Unit C age is constrained by two ^{14}C dates: 16,260 (±340) and 13,200 (±210) cal yrs BP near the bottom and the top of the unit, respectively. The uppermost Unit D is dominantly carbonate, cemented, and consists of bioclastic packstones with red algae, benthic and planktonic foraminifers, bryozoans, and Halimeda plates. Non-carbonate grains, as secondary component, are quartz, feldspar, and glauconite. The top of Unit D marking the top of the core is dated at 10,980 (±360) cal yrs BP.

The depositional history recorded in core 73 JPC starts at about 17,000 cal yrs BP (or earlier) in a back-reef subtidal environment with moderate to high energy and water depth less than 10 m (Unit A). Subsequently, with sea level at near stillstand, the abrupt increase in siliciclastics and wood debris that marks the transition to unit B suggests increased river runoff to the Gulf during a warmer and wetter Henrich Stadial 1. The appearance of planktonic foraminifers and the benthic foraminiferal assemblage shift in the overlying unit C mark a major deepening into a shelf environment, and explain the lack of ooids in this unit. This deepening of the shelf edge during Unit C is supported by its age that encompasses Melt Water Pulse (MWP) 1A. The cemented, carbonate-rich unit D with increased planktonic foraminifers as well as encrusting red algae and foraminifers points to further deepening into an outer shelf environment. Its age around 11,000 cal yrs BP suggests that this second deepening event could represent sea level rise associated with MWP 1B. Submarine cements indicate that seawater circulated through the sediments, possibly in response to the establishment of currents at the shelf break. Currents also would have prevented sediment accumulation for the last 11,000 years at this location.

CHEMISTRY OF LACUSTRINE MUDSTONES ON MARS BY THE CHEMCAM INSTRUMENT ONBOARD THE CURIOSITY ROVER

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Since its landing, the Curiosity rover has traversed 16 km spending > 1700 sols (Martian days) at the surface of Mars. On sol 750, the rover entered into continuous light-toned layers named the Murray Formation marking the base of Mt. Sharp, a 4-km high mountain where clay and sulfate minerals have been identified from orbit. This formation is dominated by mudstones and fine-grained sandstones, interpreted to be mostly lacustrine deposits formed in the beginning of the Hesperian period, ca. 3.7-3.6 Ga. This study focuses on chemical variations within the Murray Formation compared to fluvial and lacustrine sediments encountered earlier in the mission using the ChemCam instrument. The ChemCam instrument determines the chemistry of rocks using laser ablation, from 2 to 5 meters distance, over series of points with diameters close to the laser beam, ca. 0.3-0.5 mm. Bulk chemistry for each target can be established by averaging several points. All points corresponding to obvious diagenetic features are removed from the average to obtain a composition devoid of obvious post-depositional modifications. Indications of alteration from chemistry can be evaluated using various indices such as the Chemical Index of Alteration (CIA), which is defined as $CIA=100*Al_2O_3/(Al_2O_3+CaO_*+Na_2O+K_2O)$ (molar), and for which values above 50 mean an excess of Al due to alteration compared to the stoichiometry of primary minerals.

The CIA index has been below 50 for all aqueous sediments studied earlier in the mission. Starting at the location named Pahrump Hills, and then through the entire Murray Formation so far, values > 50 are frequent, especially in the recent observations over Sols 1450-1520, for which the CIA reaches frequently 60.

The increase in CIA is correlated with a lower CaO abundance (< 2%), suggesting a leaching of this element in particular, due to alteration of either plagioclase or Ca-pyroxene. Leaching of calcium may also be in relation with the density of light-toned Ca-sulfate veins observed. Starting sol 1450, these veins increasingly display a geometry sub-parallel to bedding. This apparent enhancement of Ca-sulfate-rich deposits may be linked to the depletion of calcium in the bulk rock. MgO does not show the same lower abundance (average of 4-6 wt%, with locally higher values) contrary to expectations for pyroxene alteration. However, the role of early diagenetic processes is difficult to isolate from the bulk composition and the presence of frequent Mg-rich concretions suggests that this process was an important sink for Mg. Further investigations higher in the stratigraphy, especially in the nearby hematite ridge, will enable us to refine these interpretations. In conclusion, lacustrine mudstones with CIA values reaching 60 suggest a significant weathering in an open system at the surface or close to it. These mudstones constitute an important constraint for reconstituting the paleoclimate of Mars.

CONTROLS ON CARBONATE PLATFORM GROWTH WITHIN THE LOWER CARBONIFEROUS OF THE PENNINE BASIN

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This project assesses the depositional, structural and diagenetic processes on carbonate platform evolution within an extensional basin. Syn-rift carbonate platforms often evolve from ramp to rimmed shelves, but the interplay of fault propagation, bioconstruction, volcanism and clastic interaction remain poorly described. Two late Visean (333 to 326.4 Ma) carbonate platforms are compared: the Derbyshire Platform (DP), situated in the Pennine Basin of northern England, and the North Wales Platform (NWP), located 130 km westwards. Both platforms formed during a greenhouse to icehouse transition in a back-arc extensional basin, and hosted syn-depositional normal-and oblique faulting. However, the DP was remotely landattached and experienced syn-depositional volcanism, whereas the NWP was land-attached with significant siliciclastic input and was not influenced by volcanism. This research demonstrates multivariate control on the divergent evolution of two contemporaneous carbonate platforms formed within the same basin through field-based sedimentology and stratigraphic forward modelling.

Field mapping and petrography supports that in the Asbian the windward margins of both platforms were dominated by bryozoan and coral dominated carbonate mounds with well-defined core and flank facies. Skeletal grainstone shoals infill intra-mound topography and also form sheet-like coated grain dominated sandbars in less restricted environments. Behind this margin, platform interior lime-stones record upwardshallowing crinoidal packstone-grainstone facies, capped by exposure comprising thick, clay rich and nodular, cemented palaeosols on the NWP and pot-holed limestone overlain by clay wayboards attributed to volcanic ashfalls on the DP.

A platform-wide emergent surface marks the top of the Asbian on the DP. Penecontemporaneous marine siliciclastic deposition sourced from the Wales-Brabant Massif inundated the NWP, whilst the DP was protected from this influx by an intervening basin. Brigantian migration of turbidite and fluviodeltaic systems increased water column turbidity. Subsequent facies became thinner and darker with abundant chert and Gigantoproductus brachiopods. As volcanism waned on the Derbyshire Platform, mounds became common on the platform top rather than the platform margin and formed preferentially at E-W jogs between oblique-slip faults defining intra-shelf basins. Siliciclastic poisoning and/or cessation of carbonate factories attributed to relative sea-level rise resulted in Brigantian termination of platform growth. Numerical stratigraphic forward modelling will now assess the sensitivity of carbonate platform growth and stacking to changes in relative sea level, carbonate production rate, and sediment transport rates in order to develop predictive rules for carbonate platform facies distribution in age-equivalent settings.

NEW BIOSTRATIGRAPHY AND SINGLE-DETRITAL-ZIRCON-DATING CONSTRAINTS ON THE AGE AND ORIGIN OF ALLOCHTHONOUS BAUXITE DEPOSITS OF LANGUEDOC (SOUTH OF FRANCE): GEODYNAMIC CONSEQUENCES

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In southern France, the dominantly carbonate Jurassic to Neocomian formations accumulated during the thermal subsidence phase of the Tethyan passive margin. This sequence is truncated by a major erosional/weathering hiatus, outlined by bauxite deposits. The hiatus extends from to Dogger to Maastrichtian in the Bédarieux basin, but it is restricted to the “mid” Cretaceous in Provence. The inversion of the Tethyan margin, refered to as the Durancian Isthmus, is contemporaneous with 1) rifting and mantle exhumation in the Pyrenees, 2) Variscan basement denudation in the southern Massif Central revealed by AFT analyses and 3) subsidence along EW-oriented basins from the Northern Pyrenees, across to southern Provence. A geodynamic link between such events that affected southern France in the Aptian to Cenomanian interval is still discussed. Due to their intermediate location, the bauxite basins of Languedoc offer the opportunity to address this question.

The allochthonous bauxites deposits of Languedoc represent reworked weathering horizons derived from either neighbouring Variscan basement, or from the marly limestones of Neocomian age which may possibly be extended across the whole area. New age brackets for bauxite deposition and sedimentary source of the reworked alterites origin provide strong constraints on the geodynamic framework.

We precise the chronology of the event with news biostratigraphic results from the formations that seal the bauxite deposits from Villeveyrac Basin. In order to investigate the origin of the reworked bauxites, we performed LA ICP-MS single dating of detrital zircons from 3 karst bauxite basins, stretching from Bédarieux (close to present-day Variscan basement outcrop: Montagne Noire) to Cambelliès (close to the Mediterranean Sea).

These new results are integrated into a geodynamic framework of southwestern Europe during the critical latest Neocomian episode.

LAKE LEVEL FLUCTUATIONS AND RAINFALL VARIABILITY AT LAKE TRASIMENO (ITALY) INFERRED FROM OSTRACOD ASSEMBLAGES

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The endorheic and shallow (ca. 6 m maximum depth) Lake Trasimeno (central Italy) is highly sensitive to local environmental changes, as it strictly depends on local meteorological conditions. A multiproxy approach in a sediment core (Co1320, 859 cm) retrieved in the deepest part of the lake, has been used to reconstruct the climate history of central Italy during the Late Pleistocene to Early Holocene period (ca. 47,000 – 9,000 cal yr BP). Ostracod assemblages and sedimentological data (lithology and carbonate content) have been used to infer past hydrological changes in the area. The ostracod community was analyzed throughout the core using diversity indexes and multivariate analyses (Cluster and PCA). Three main associations linked to lake level and salinity variations were recognized: 1) the *C. torosa* association, indicating permanent lacustrine conditions with high lake levels and low salinities; 2) the *S. aculeata* association, linked to a very shallow/ephemeral lake with higher salinity conditions and 3) the *S. aculeata-E. mareotica* association pointing to ephemeral conditions and the highest salinities. Furthermore, the presence of *C. fuscata* and *L. friabilis* during wide parts of the Late Pleistocene indicate lower temperatures than present days. Alternations of these three ostracod associations compares well with the oxygen isotope curve from Greenland (NGRIP) and are thus interpreted as climatically driven. In concert with XRF core scanning data from previous studies on the same core (Rb/Sr ratio), high and low lake levels at Lake Trasimeno are linked to humid and arid periods in central Italy that correlate with the Greenland Interstadial/Stadial (GI/GS) climate variability during the Last Glacial period. At the Holocene transition (Termination 1), the ostracod associations indicate a delay in the increasing warming and humidity with respect to the NGRIP temperature record.

TESTING 3D ELECTROMAGNETIC DATA AND TECHNIQUES AS A TOOL FOR HIGH-RESOLUTION BATHYMETRY IN TROPICAL CORAL REEF ENVIRONMENT

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In tropical coral reef environments, surveying techniques that provide high-resolution data on the seafloor morphology are traditionally associated with high logistical costs (USV, LIDAR or satellite bathymetry) and with high difficulties in obtaining shallow bathymetry where submerged hazards are present. Acoustic methods in these environments (using either singlebeam or multibeam echosounders systems) require a big number of routes to reach a high-resolution bathymetry and in addition, submerged obstacles limit their operability.

Several studies on land environment have confirmed the accuracy of Structure from Motion (SfM) techniques forhigh-resolution 3-dimensional (3D) topographic reconstruction and analysis, and in some cases found SfM to be equivalent to LIDAR techniques. In the last 5 years this methodology started to be applied in ultra-shallow marine environment, using snorkeling transect with underwater cameras on coral reefs, where ship-based survey is unfeasible. The small spatial extent of the resulting 3D models, in this particular underwater context, is the main limit of this technique.

Our methodology aims to increase the coverage of SfM techniques in ultra-shallow water environment coupling the snorkelling video transect with a commercial Unmanned Aerial Vehicle (UAV) survey in order to obtain: (1) a complete sub-metrical resolution DEM (Digital Elevation Model), and (2) provide unique opportunities to better quantify topography, rugosity and other structural characteristics of this peculiar marine environment.

This study utilized SfM 3D reconstruction software tools to create DEM of a coral reef of a small Maldivian island (Magoodhoo Island, Faafu Atoll) and used a proper GIS-based tool to extract geomorphometric parameters.

The use of geomorphometric analysis on the resulting DEMs allowed to quantitatively asses the structural complexity of the surveyed reef, that can be integrated with other physiological and ecological parameters to increase our knowledge in understanding the geomorphic process and the evolution of this vulnerable carbonate depositional system.

SPATIO-TEMPORAL RELATIONSHIPS BETWEEN GAS, HYDRATE SYSTEM, SEDIMENTARY AND TECTONIC FEATURES IN THE OFFSHORE ROMANIAN AREA (BLACK SEA)

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The continental slope along the offshore Romanian area (north-east of the Danube canyon, northwestern Black Sea) is characterised by abundant fluid expulsion features in a complex environment of canyons/valleys and submarine landslides. The precise interaction between turbidite activity, sedimentary instabilities, fault activity and gas/gas hydrate dynamics is still poorly documented in this area. This study is then focused on the spatio-temporal relationships between the gas seeps and gas hydrates distribution, the sedimentary bodies and the tectonic features.

Seismic data (2D High Resolution and near-bottom SYstème SIsmique Fond SYSIF) acquired during the GHASS campaign (2015) allowed to identify the geometry and the relative chronology of sedimentary bodies such as canyons/paleo-valleys and associated channel-levees systems and Mass Transport Deposits (MTD). The different sedimentary discontinuities (erosional surfaces, scarps related to MTD, channel sidewalls) and faults have been distinguished. These data provided a map of the gas hydrate extent and allowed to precise the zones with evidence of free gas in sediments. Finally, the types of permeable and seal layers have been defined.

This analysis reveals that the most important control on gas seep distribution is the gas hydrate extent. The majority of the gas seeps recorded in the water column is located at a water depth less that the landward termination of the Bottom Simulating Reflector (BSR). This characteristic provides new evidence that gas hydrates play the role of an efficient seal layer preventing gas to flow until the seafloor and the water column. Higher up on the continental slope, the gas seeps are in association with sedimentary discontinuities such as channel sidewalls and slide scarps whereas stacked levees draped by hemipelagic deposits (i.e. fine sediments) constitute transient seal layers. The complex pattern of sedimentary discontinuities is inherited from the history of turbidite activity leading to the formation and migration of valleys during the last low stand and sometimes disturbed by sedimentary instabilities. Indeed, five valleys, including the most recent Danube valley, have successively developed on the continental slope and migrated firstly northeastward and then southwestward. These valleys have developed over several wide MTD (> 50 km^3 for the total volume in the area) associated to a basal unconformity which corresponds to an erosional surface. The regional character of this surface with associated MTD observable from the uppercontinental slope down to thedeep basin raises the question of its origin. Indeed, this surface seems represent both a sequence boundary related to a sea level fall and a decollement surface linked to major instabilities. These submarine landslides may be linked to gas hydrates destabilisation which would have occurred before the turbidite activity, potentially during the last interglacial maximum. Recent submarine landslides occur on the seafloor mainly on valleys sidewalls and weaken the area which could be prone to easily slide in the future. Numerical modelling and new dataset from sediment cores recovered during the GHASS campaign and still in the process of analysis should allow to precise the relationships between sea level variations, gas hydrate dynamics and slope instability.

ASTRONOMICAL TUNING AS A TOOL TO DISENTANGLE VARIABLE SEDIMENTARY CONDITIONS AND STRATIGRAPHIC GAPS IN THE MIDDLE EOCENE OYAMBRE SECTION (NORTHERN SPAIN)

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In 2015 an integrated magnetobiostratigraphic study of the middle Eocene Oyambre section (N Spain) showed its potential to host the Global Stratotype Section and Point (GSSP) for the Bartonian stage. In order to complement this work, this new study tackles the orbital tuning of the Oyambre section with the aim of improving its chronostratigraphic calibration. The 108 m thick succession studied is composed of hemipelagic limestone-marl alternations and interbedded turbidites. The limestone-marl couplets are related to astronomical precession cycles of ~20 ky duration, whereas larger-scale bundles record the ~100 kyr eccentricity modulation. A total of 855 samples from the hemipelagic lithologies were collected for bulk lowfield magnetic susceptibility analysis, sampling resolution being high enough to reveal precessional scale alternations.

According to data from the present study, variations in thickness of the limestone-marl couplets suggest that sedimentation rate was not constant during the formation of the lower part of the succession, a situation which generally hampers a reliable cyclostratigraphic analysis. Despite this difficulty, the application of appropriate spectral analysis and filtering techniques to the high-resolution magnetostratigraphic data yielded an accurate (even at 20 kyr precessional scale) astronomical calibration of the C20r/C20n transition. These results can be combined with previously published information from ODP sites 1260 and 1263 in order to assess the reliability and accuracy of existing astronomical solutions.

The upper part of the succession (C19r-C18r interval) contains abundant turbidites and was found to have been affected by two faults, which may hinder cyclostratigraphic analysis. In addition, previous magnetostratigraphic and biostratigraphic results were not conclusive in this interval, making the chronostratigraphic calibration even more difficult. Despite these limitations, a plausible orbital tuning was worked out, which allowed the stratigraphic gap produced by the two faults to be calculated.

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COULD MICROPEARLS BE PRESERVED IN THE SEDIMENTARY RECORD?

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Recently, some unicellular eukaryotic phytoplankton species of freshwater lakes (e.g. Tetraselmis cordiformis) have been described to form intracellular mineral inclusions composed of amorphous calcium carbonates, called micropearls. This new type of biomineralization shows internal nanoscale oscillatory zoning due to variations in the concentration of Ba, Sr and Ca. One of the questions raised by the description of this new biomineralisation process is the long-term fate of the micropearls.

Some micropearls observed in Lake Geneva (Switzerland) present a Ba/Ca ratio which is up to 800 000 times higher than in the surrounding lake water. Thus, formation of micropearls, even considering a possible solid solution mechanism, requires a chemical intracellular environment different from the surrounding water.

The organisms forming the micropearls must therefore highly concentrate specific elements (e.g. Sr and Ba). Observations showed that a possible fate for the micropearls is to be dissolved if the cell ruptures and the micropearls enter in contact with the surrounding water, probably because they are no longer in chemical equilibrium within the environment in which they were formed.

Nevertheless, it seems that the micropearls can evolve into other more stable mineral forms while still within the cell, thus highly improving their chances to avoid dissolution when the cell envelope is either broken or consumed by bacteria after alga death. This suggests that some "evolved" micropearls might be preserved in the sediments. Given the wide geographical distribution of the organisms forming the micropearls, the recognition of their fossil equivalent would be of interest for sedimentology interpretation.

LACUSTRINE STROMATOLITE LAMINATION OF THE MIOCENE IN THE SIERRA DE ALCUBIERRE (EBRO BASIN, SPAIN)

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This study provides information on the environmental and temporal significance of lacustrine stromatolite laminations of a Miocene succession found in the central part of the Cenozoic Ebro Basin (northeastern of Spain), where lacustrine stromatolites are common. In the Sierra de Alcubierre, stromatolites are common in three genetic stratigraphic units (i.e., T5, T6, and T7, spanning from chron C6A to C5AC) that are found in a 630 m thick succession of distal alluvial and lacustrine deposits. The lacustrine deposits correspond to various carbonate and sulphate depositional environments that developed under different water levels. Stromatolites, mostly consisting of calcite and lesser amounts of dolomite, developed when the lake levels were between high (freshwater carbonate environment) and low (sulphate environment). They are associated with laminated limestones and dolostones (i.e., with lenticular and wavy stratification, hummocky-cross stratification and horizontal lamination), all of them representing saline carbonate, closed-lake deposition. Stromatolites occur 1) at the base of facies associations that represent deepening processes, and 2) alternating with laminated facies through shallowing processes. Three morphological types of stromatolites are present: 1) thin planar bodies (mm to 10 cm thick and small in extent), 2) bioherms, and 3) biostromes (up to 30 cm thick), which reflect water level, salinity, and hydraulic dynamics. These stromatolites, formed largely of micrite and microspar, are characterized by different orders of laminae. Simple laminae can be: dark dense laminae (0.07 to 0.5 mm thick), light dense laminae (0.11 to 1.89 mm thick), and light porous (clotted micrite) laminae (0.1 to 1.35 mm thick). These simple laminae can be grouped into dark (0.28 mm to 2.76 mm thick) and light (0.65 mm to 6.36 mm thick) composite laminae in which either the dark or the light simple laminae dominate. Although the laminations are defined by an alternation of dark and light laminae, the combination of the several types of simple and composite laminae shows different lamination patterns (i.e. cyclothemic and alternating). Stable isotope analyses ($\delta^{13}C$ and $\delta^{18}O$) of the dark and light composite and simple laminae in the calcite stromatolites of units T5 (2 samples; 37 laminae) and T6 (3 samples; 32 laminae) reveal cyclic isotopic variations that follow the textural variations through time. The light laminae have lower $\delta^{13}C$ and $\delta^{18}O$ (mean $\delta^{13}C_{light\text{-}lam}$ = -1.34, $\delta^{18}O_{light\text{-}lam}$ = -4.38 ‰ V-PDB; N= 35) than the dark laminae (mean $\delta^{13}C_{dark\text{-}lam}$ = -1.10, $\delta^{18}O_{dark\text{-}lam}$ = -3.34 ‰ V-PDB; N= 34). The effect of temperature on oxygen fractionation is difficult to discern in closed basins affected by intense evaporation, and probably temperature and evaporation would produce opposite effects, thus smoothing the cyclic $\delta^{18}O$ variation. The correlation between $\delta^{13}C$ and $\delta^{18}O$ (r= 0.41; N= 69 laminae) suggests that the precipitation/evaporation ratio (P/E) was the main control on the short-term isotopic evolution of the saline carbonate lake. Therefore, light laminae would correspond to more humid conditions (i.e., rainy), with higher soil-derived CO_2 input, whereas the dark dense laminae formed under drier conditions. These variations may represent seasonal and interannual changes.

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THE PERMIAN PHOSPHORIA ROCK COMPLEX: A RECORD OF THE INTERACTION OF THE ARID WESTERN PANGAEAN LANDMASS AND PANTHALASSA

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The Phosphoria Rock Complex is a middle to upper Permian succession of organic-rich mudstone, phosphorite, chert, open-marine and restricted carbonates, evaporites, red beds, and shallow-marine siliciclastics that accumulated in a broad epicontinental sea, the Phosphoria Sea, that spanned the northern tropical latitudes of Pangaea during a time of global climate change. During the early Permian, the Pangean tropics possessed a seasonal climate and glaciers grew in southern Gondwana. Following the demise of ice sheets, the climate transitioned to hothouse conditions. Daily highs of over 40°C in the US midcontinent caused aridification and significant environmental and floral changes. Within this context of global change, the Phosphoria Rock Complex formed in a unique oceanographic setting with no modern analogue. Upwelling of deep water, impingement of an intermediate water mass, salinity stratification caused by inverse estuarine circulation, and temperature stratification have all been proposed to explain the facies trends within the Phosphoria Sea, but a consensus has not been reached. Moreover, the role of Permian climate change has not been widely investigated as a significant influence in the uniqueness and evolution of the distribution of facies in the Phosphoria Rock Complex. The objective of this study is to elucidate the influence and interrelation of the evolving Permian climate and the unique paleoceanography of the Phosphoria Sea. This is done through the combination of field and core study focusing on deposits in the Bighorn Basin of northern Wyoming, USA, which record conditions along the eastern margin of the seaway. A holistic approach that integrates sequence stratigraphy, facies analysis, petrography and geochemistry with literature review is used to place the Phosphoria Rock Complex into the global context of the dynamic Permian climate. Results reveal that the Phosphoria Rock Complex accumulated in settings where oceanographic conditions were both geographically and temporally variable. Cherts and phosphorites in the furthest offshore deposits grade landward into heterozoan carbonates with widespread authigenic mineralization (e.g., phosphate and glauconite) and then into peritidal and sabkha carbonates with significant microbial influence. Further landward, the Phosphoria Sea was bordered by supratidal to terrestrial aeolian red siltstones with interbedded evaporites and carbonates that accumulated in alkaline coastal salinas. The terrestrial deposits were part of the widespread western Pangean desert that extended across much of the semiarid to arid western part of the supercontinent. The terrestrial and peritidal (sabkha) deposits record the influence of this arid Pangean climate on coastal and shallow-marine paleoenvironments of the Phosphoria Sea. Comparatively, offshore heterozoan carbonates and bioelemental deposits record nutrient-rich water that was supplied by the Panthalassan ocean and caused phosphogenesis over a greater area than on modern continental shelves. The interaction of these climatic and oceanographic controls largely dictated the nature of the Phosphoria Sea depositional environments, including their geographic and temporal variability. The Phosphoria Rock Complex, thus, remains an important late Paleozoic case study in the interaction of the Permian climate with unique paleoceanographic conditions.

THE ROLE OF PALEOCEANOGRAPHY AND EOGENETIC ALTERATION IN INFLUENCING DIAGENETIC PATHWAYS IN CARBONATE FACIES OF THE PHOSPHORIA ROCK COMPLEX, BIGHORN BASIN, WYOMING

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The Phosphoria Rock Complex is a succession of phosphorite, chert, organic-rich mudstones, openmarine and restricted carbonates, evaporites, red beds, and shallow-marine siliciclastics. It accumulated in the Phosphoria Sea, an epicontinental sea located along the tropical western Pangaean margin during the middle-late Permian. The Phosphoria Rock Complex has attracted significant attention due to economic phosphorite deposits and a prolific petroleum system. Within the Bighorn Basin of northern Wyoming, the Phosphoria Rock Complex is predominantly carbonates, ranging from offshore brachiopod-bryozoanechinoderm facies to shallow-marine molluscan facies to peritidal (sabkha) facies. Past work on the Phosphoria Rock Complex has suggested that it accumulated in a unique oceanographic setting with no modern analogue. Upwelling of deep nutrient-rich cold water, impingement of an intermediate water mass, and inverse estuarine circulation causing salinity and/or temperature stratification have all been proposed as the cause of the atypical oceanography. Within the Bighorn Basin, carbonate facies suggest accumulation under oceanographic conditions that varied across the sea as controlled by the interaction of the large-scale paleoceanographic controls and regional climate. Importantly, these include an onshore decrease in nutrient content, increasing water temperature and salinity, and increasing carbonate saturation state. The variance in these factors strongly impacted the early diagenesis of the carbonate facies. Understanding the role of variable early diagenetic processes in controlling subsequent diagenetic alteration is important in understanding the development of reservoir lithologies and is fundamental in determining how representative the modern rocks are of the original depositional facies, an important aspect in reconstructing the atypical paleoceanography. As such, the objective of this study is to correlate facies and inferred oceanographic conditions to early diagenesis and the influence of eogenesis in controlling the subsequent diagenetic pathways in the carbonate facies. This is done through the comprehensive evaluation of the sedimentology and stratigraphy of the Phosphoria Rock Complex across the Bighorn Basin. Sedimentologic observations are combined with petrographic analysis using microfacies analyses, petrographic staining, cathodoluminesence, energy dispersive x-ray spectroscopy, and stable isotope analyses. Deposition of calcitic heterozoan carbonates in cooler, nutrient-rich, relatively deep water led to authigenic phosphate, glauconite, chert, and iron minerals replacing skeletal grains and cementing intraskeletal porosity. This largely limited subsequent burial diagenesis to matrix alteration and pervasive fabric-destructive dolomitization. In some cases, authigenic minerals remain as the only vestige of the original depositional fabric due to their greater stability. Molluscan facies accumulated where water chemistry was sufficiently favorable and allowed aragonitic skeletal growth. This led to increased conventional marine diagenesis (i.e., micrite envelopes and isopachous cement). Furthermore, grains did not undergo authigenic replacement, increasing their susceptibility to later alteration involving aragonite dissolution, cement precipitation, and pervasive fabric-destructive dolomitization, with variable preservation of original facies. Comparatively, peritidal facies contain coated grains and peloids with significant microbial influence. Prolific synsedimentary diagenesis is evidenced by micritic cements, internal sediment, and teepee structures. Grains also underwent widespread contemporaneous dolomitization. The early dolomitization and cementation limited later alteration primarily to dolomite recrystallization and minor occlusion of open porosity. Thus, there are important relations between paleoceanography, eogenesis, and the modern rock properties.

IMPACT OF EMERSION EVENT ON THE DIAGENETIC HISTORY AND THE PORE TYPE AND ACOUSTIC PROPERTIES ACQUISITION OF NON-TROPICAL CARBONATES (CAPE RANGE, WESTERN AUSTRALIA)

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The acoustic response of sedimentary rocks is related to their mineralogy, porosity amount and pore type. In carbonate rocks these properties are controlled by the initial deposition parameters but often even more by the diagenetic history, due to their sensitivity to chemical processes. Diagenesis, by multiple cementation and/or dissolution phases (modulated by initial mineralogy), strongly controls the pore type variations and the pore network acquisition. Besides, the non-tropical carbonates often display heterogeneous mineralogy that can raise more complexity.

Oligo-Miocene carbonates from the NW-Shelf of Australia present non-tropical facies deposited along a ramp which have underwent highly contrasted diagenetic processes. The uppermost sedimentary unit is characterized by completely different diagenetic processes compared to the lower ones.

To decipher the links between the acoustic properties and the complexity of these rocks we performed 50 ultrasonic velocity measurements on plugs sampled from outcrops. Then thin section 2D analyses and 3D CT-scan models made from the same plugs were used to accurately characterize the dominant pore type of each sample. Their diagenetic history was reconstructed from field, cathodoluminescence observations and stable isotopes geochemical analysis.

The acoustic data were interpreted in the light of the EPAR (Equivalent Pore Aspect Ratio) proxy that allowed us to deconvolve combined effects of mineralogy and pore types on ultrasonic velocity. First, we underline by comparing the computed EPAR values with the actual dominant pore type the EPAR proxy is relevant to retrieve pore type information from acoustic data only.

Second, we emphasize the importance of emersion events on the acoustic response acquisition of these rocks. Here, a middle Miocene emersion and erosion phase explains the highly contrasted diagenetic history observed, by impacting both early diagenetic dissolutions, the level of compaction/pressure– solution, and the initial mineralogy. Preliminary results show that geochemical signature, characterized by meteoric water influence, is compatible with this emersion event.

THE PORAT STAGE IN THE DEVELOPMENT OF THE PLIOCENE-QUATERNARY FLUVIAL SYSTEMS OF THE SOUTH-EAST CARPATHIAN FORELAND

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Progressive uplift of orogens along the northern margin of the subducting Tethys Ocean led to the separation of a separate biogeographic region name Paratethys in the Oligocene. The Paratethys initially stretched from central Europe far into central Asia. Progressive basin retreat and restriction during the Miocene, Pliocene and Quaternary, eventually resulted in the modern semi-isolated and isolated intra-continental seas of the Mediterranean, Black Sea, and Caspian Sea. Despite the great volume of stratigraphic and paleontological publications on the Eastern Paratethys, the sedimentary response to basin retreat remains generally very poorly documented. Our resent research in the SE Carpathian foreland has shown that the first stages of expansion of the terrestrial realm into the NW Black Sea happened through deposition of the Balta Fm, which represents a vast prograding Late Miocene fluvial-deltaic system.

The current study reveals the next, Pliocene to Early Pleistocene stage (Porat Stage) in the evolution of the SE Carpathian Foreland, when the previously vast alluvial plain reduced in size and became fragmented, more fluvially dominated and localized in the lower reaches and mouths of the direct predecessors of the modern rivers. The Porat Stage is illustrated by the stacked alluvial Porat Fm occupying the Siret-PrutDniester interfluves. It was studied using lithofacies and mode of occurrence analyses of numerous outcrops and borehole sections. This was complemented by an essential revision of the regional-local stratigraphy and a review of the lithological data in literature.

The Porat Fm accumulated in close connection with the further reduction of the Paratethys residual basins, infilling the Dacic Basin and possibly the North-Western part of the Black Sea Basin. Its mode of occurrence and lithology reflect several episodes of disjunction and re-connection of these water bodies through the ancient Reni Strait (Galaţi passage or Scythian Gateway). It also shows the final breakout of the Danube to the Black Sea. In the final stage of its evolution, the Porat fluvial system converted to the narrow, familiar, terraced river valleys so characteristic for the Quaternary. Tectonic interaction between the active Carpathian Orogen and Black Sea Depression on the one hand and the passive East-European and Scythian platforms on the other has had a marked influence on fluvial development. Another important factor was the abundant and continuous water supply, which was much larger than in the subsequent Middle-Late Pleistocene and Holocene periods.

PETROPHYSICAL PROPERTIES AND THEIR RELATIONSHIP TO CARBONATE ROCK TYPES OF THE OCEANIC REEFAL ISLAND: A CASE STUDY OF THE DAITO FORMATION, JAPAN

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Some Cenozoic carbonate buildup reservoirs, which have vuggy-dominated pore system, show complicated reservoir quality and distribution due to near-surface diagenetic modification including a subaerial exposure event. In this study, we evaluate the effects of near-surface diagenesis on a pore system of the Miocene to Pleistocene Daito Formation carbonates on Minami-daito Island as an analog for carbonate buildup reservoirs. This island consists of uplifted coral reefs, and an outer rim zone and an inland area of the island correspond to reef margin and platform interior of a carbonate buildup, respectively.

Petrological study revealed that dolostones of the Daito Formation, which typically consist of fabricpreserved dolomites and dolomite cements, have the similar pore system to limestones. Dolomitization in the formation has occurred on the outer rim zone and in eastern part of the inland area. The dolomite distribution is controlled by the reef topography rather than the facies distribution.

Porosity and permeability of plug cores from surface and core samples range from 0.7 to 55.8% and from < 0.01 to 26.091 mD, respectively, and those of limestones tend to be higher than those of dolostones. The porosity and permeability of both limestones and dolostones in the inland area show obviously higher values than those in the outer rim zone, and especially the values tend to be higher in western part of the island. In bulk density data, the values of the outer rim samples show higher values than those of the inland samples within each lithology, indicating that the porosity decrease from the inland area to the outer rim.

Porosity and permeability relationship of the formation is strongly influenced by pore system and degree of cementation. The carbonates are divided into 4 rock types (RTs) based on pore characteristics (RT 0; cement-dominated, RT 1; grain-moldic pore dominant, RT 2; coral-moldic pore dominant and RT 3; vuggy pore dominant). RT 0 and 1, which are composed of an isolated-pore system, generally show permeability lower than 3 mD regardless of porosity values. The rock types are mainly distributed in the outer rim zone. Whereas, RT 2 and 3 are plotted on moderate to excellent porosity-permeability area, because these have a well-connected-pore system. The rock types are widely distributed in the inland area.

From the above results, the reservoir quality and distribution are controlled by multiple phase nearsurface diagenetic events related with the reef topography, facies and dolomitization. The reef topography has the most impact on the degree and extent of diagenesis. Calcite and dolomite cementations have been developed on the outer rim zone by active fluid circulation and formed the RT 0 and RT 1 rocks. On contrast, in the inland area, progressive dissolution associated with subaerial exposures and soil development have created well-connected pore system and formed the RT 2 and 3 rocks.

MULTIPROXY CORRELATION SCHEME BETWEEN TERRESTRIAL AND MARINE PALAEOCENE SUCCESSIONS IN THE NORTH PYRENEAN FORELAND BASIN (FRANCE)

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Paleocene is a particular epoch in the Pyrenean orogeny as it is often considered as a time of quieter tectonic activity between the two major phases of compression. The North Pyrenean Foreland Basin (NPFB) is an E-W trending basin with a carbonated marine realm to the west (Petites Pyrénées, Ariège) and a terrestrial domain to the east (Corbières, Aude). Lower rates of sedimentation in the NPFB are reported but the stratigraphy within the successions is not well constrained as a large part of the basin fill is of poorly-dated terrestrial sediments. The aim of this study is three-fold: 1) refine the stratigraphy of the Palaeocene in the NPFB, 2) define a high-resolution correlation scheme between the terrestrial and marine successions and 3) finally best reconstruct the foreland basin architecture.

Sedimentological field analysis was conducted on 9 logged sections, of roughly 250 to 480 m in thickness, together with thin sections analysis, in order to define facies association, depositional environments and high-resolution sedimentary sequences. $\delta^{13}C$ chemostratigraphy, palynology and foraminifera biostratigraphy were performed on three sections (Mas d'Azil, Lairière, Peyrolles) to refine the regional stratigraphy initially based on biostratigraphy in the marine and lacustrine carbonates. The 3 western sections show shallow marine carbonate platform facies and subordinate lacustrine and floodplain facies, whereas the 6 eastern sections present floodplain facies, intercalated with fluvial channels, subordinate lacustrine facies, and locally punctuated by mouthbar and shallow marine carbonates. In our study a hiatus marked the Early Danian followed by four major sequences in the Mas d'Azil section. In Lairière, sequences in the Danian terrestrial deposits show a major hiatus in the Late Danian. At this location, the Selandian has been identified in the succession through a short positive followed by a very negative $\delta^{13}C_{org}$ excursion that are well correlated to a key marine section (GSSP of Zumaia, Spain), and confirmed by biostratigraphic markers. This Selandian transgressive sequence is recognized in two other sections, at the fully marine Mas d'Azil section to the west and at the Peyrolles section, south of Lairière. During the Thanetian, sea-level variations are frequent and reach the Corbières during two short episodes, while the western study area is fully marine. The earliest Eocene is also recorded in terrestrial and shallow marine facies of the Corbières through the CIE of the PETM.

The data obtained from the Paleocene of the NPFB enables to present a new and refined high-resolution correlation scheme more than 20 years after the last regional studies conducted by Y. Tambareau and J.-C. Plaziat. The North Pyrenean Palaeocene succession is also an example of low energy fluvial system terminating into a carbonate platform that questions how fine-grained clastics input do not affect the growth of the carbonate platform. Thickness variation in the Palaeocene successions from 250 m to 400 m also shows that subsidence rates vary along-strike the orogeny. In this system, sea-level variations and tectonic subsidence are two main factors that control the sedimentary sequences.

UPWARD MIGRATION OF UNUSUAL MG-SO_4 BEARING FLUIDS FROM UNDERLYING MESSINAN SALT GIANT: AN EXAMPLE OF ON-GOING SUBSURFACE DIAGENETIC ALTERATION OF EARLIEST PLIOCENE/LATEST MIOCENE SEDIMENTS AT DSDP LEG 42A, SITE 374, IONIAN ABYSSAL PLAIN

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Deciphering exact mechanisms for the formation of massive dolomite deposits remains an out-standing enigma in sedimentary geology. However, the common association of dolomite with salt giant deposits has long been recognized. A noteworthy 33.5 m-thick dolomite sequence capping the salt giant of the Messinian Salinity Crisis (MSC: 5.97-5.33 Ma) was recovered during drilling across the Miocene/Pliocene boundary at DSDP Leg 42A, Site 374 in the Ionian Abyssal Plain (Hsü, Montadert et al., 1978, Initial Reports DSDP, Vol. 42, Part 1). At this location, the lowermost Pliocene sequence (Unit II, Core 11, Section 2: 373 to 381.5 mbsf) comprises a dolomicrite with an unusual crystal morphology, which is a diagenetic replacement product of the original pelagic calcite ooze. The underlying end Messinian dolomitic mudstone with minor gypsum layers (Unit III.a, Cores 12-15: 381.5 to 406.5 mbsf) contains Ca-rich dolomite with white spherules (up to 4-mm diameter) of lueneburgite [$Mg_3(PO_4)_2B_2O(OH)$ x 6H2O] scattered throughout. Both the lueneburgite and gypsum within Unit III.a dolomitic mudstone sequence were interpreted to have a secondary origin. Unit III.a dolomite was considered to have formed in alkaline lakes with reduced salinity, collectively known as the "Lago Mare". Thus, Unit III.a sediments were deposited as a transitional facies between the MSC evaporite complex and the more open-marine Pliocene pelagic sediments. Although the geographic limits of this lacustrine basin are not well-defined by seismic data, a thin undeformed MSC upper unit apparently overlays the MSC salt body implying that the dolomite mudstone sequence could be extensive in thickness and areal extent, representing a major dolomite formation.

Additionally, the original shipboard interstitial water geochemical profiles indicate that saline brine is diffusing upwards from below and into the early Pliocene dolomicrite sequence. Modern bacterial sulfate reduction in this boundary zone between the evaporitic dolomite and normal pelagic sediments is reflected by a significant decrease in sulfate concentrations, whereas the chloride profile remains constant. It was previously concluded that the lowermost Pliocene marine sediments of Unit II had been dolomitized after burial as a consequence of ionic migration across a steep Mg-concentration gradient. Also, Unit III.a lueneburgite is a secondary product precipitated from the upward migrating brines derived from the underlying evaporites apparently composed of highly soluble Mg-and B-salts. Furthermore, triple oxygen and hydrogen isotope analyses of the hydration water measured for gypsum samples from Site 374, Cores 11-12 and 16-20 indicate post-depositional isotopic alteration by non-evaporated waters.

In summary, biogeochemical conditions promoting subsurface diagenetic alteration of earliest Pliocene/latest Miocene sediments appear to be active at present. We propose that, at the location of DSDP Leg 42A, Site 374, modern dolomite precipitation is occurring and the site is a "natural laboratory" in which to investigate the biogeochemical phenomenon associated with subsurface diagenetic dolomite formation in the context of a salt giant deposit. This location is definitely a worthwhile site to be considered for reoccupation during future Mediterranean drilling campaigns, as it may provide an actualistic model for the origin of massive dolomite deposits associated with other salt giants in the rock record.

EVOLUTION FROM PONDED TO TORTUOUS TO UNCONFINED SEDIMENTATION IN A MARINE TRENCH-SLOPE BASIN: EXAMPLES FROM THE EAST COAST BASIN OF NEW ZEALAND

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Studies of the stratigraphic development of trench-slope basins are important to enhance our understanding of the of deep-marine sedimentary processes in active margin settings, which often are considered prospective, e.g. the Sinú Accretionary Prism, offshore Colombia. Here we present the results of detailed field studies on Miocene outcrops of the Akitio, Coastal and Tawhero mini-basins of the East Coast Basin of New Zealand. This region offers insights to the evolution of accretionary wedge systems, allowing investigations of autocyclic (e.g. mass-wasting) vs. allocyclic (e.g. tectonics) controls on sedimentation at subduction margins.

Sedimentary logging of over 3000 m of stratigraphy at bed-for-bed scale (1:50) was conducted in lateral and longitudinal transects across the region. All sedimentary structures, ichnofabrics, and over one thousand palaeocurrent indicators were recorded to define a series of twenty-five lithofacies associations. Digital mapping of lithofacies associations was carried out to define their spatial distribution. Access to extensive biostratigraphic data was provided by the Geological and Nuclear Sciences (GNS) of New Zealand to determine the temporal distribution of elements. Lithofacies associations may be used to interpret the depositional system at any one time in the basin history, which is dominated by deep-marine strata, but punctuated by at least five shallowing-up cycles and unconformities. Initially, in the lowermost Miocene (Aquitanian to Lower Burdigalian), the basins were filled with a series of thin grading to thick-bedded turbidites, which show truncation at basin margins, thickening away from onlap surfaces and suggest a ponded system. Basin margin settings also show significant remobilisation of sediment and reworking of older, footwall stratigraphy. Upper Burdigalian sequences demonstrate the development of laterally extensive thick-bedded sandstones which may (proximal lobe) or may not (distal lobe) show significant amalgamations. The eastern margin of the Akitio Basin of this age exhibits evidence of major bypass conduits, which may be associated with a channel-levee complex in the outboard Coastal Basin. Middle Miocene (Langhian to Serravallian) strata are dominated by thinbedded, mud-rich sediments, which show extensive remobilisation forming mass-transport complexes (MTCs) up to 150 m thick. Mapping of narrow corridors of lenticular sandstones has documented six submarine channel systems traversing the Middle Miocene basin. Basin amalgamation in the Upper Miocene (Tortonian to Messinian) resulted in the deposition of unconfined turbidite systems, with megabeds up to 31 m thick ponding above MTCs. Numerous sediment input and output conduits illustrate that sediment pathways between mini-basins in accretionary margins can be intricate.

These results demonstrate a dynamic evolution of the basin fill and highlight the complexity of deepwater stratigraphy in trench-slope basins. Modelling of this complexity is essential to unlock the potential of deep-water fold-and thrust belts, particularly in frontier exploration areas, such as the East Coast and Pegasus basins offshore New Zealand. In addition to providing analogues for basin fill, field studies provide insights to sediment bypass and delivery to outboard basins. Integration with sea-floor and 2D seismic data will allow further refinement of the evolution of stratigraphy in prospective outboard basins and allow assessment of evolving basin structure and sedimentation towards the trench-slope terminus.

DID YOU SAY 'FAST'? EARLY DIAGENESIS IN SUB-RECENT LACUSTRINE SEDIMENTS OF LAKE VAN

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Soft, unlithified sediments recovered from modern lakes rarely offer clear evidence of diagenetic alterations. We document, for the first time, products of early diagenesis in the deep lacustrine setting of Lake Van. Lake Van, cored in 2010 in the frame of the ICDP PALEOVAN project, is a terminal, alkaline lake in Eastern Anatolia, Turkey. Its carbonate inventory consists of [(1)] primary phases: inorganic calcite and aragonite precipitating in surface water, and low-Mg calcite ostracod valves formed at the sediment-water interface; and [(2)] secondary phases: early diagenetic dolomite forming in the sediment pores and aragonite encrustation of ostracod valves and organic remains. Here we focus on aragonite encrustations.

Encrusted grains appear episodically in Lake Van sediments younger than 270 ka, and their occurrence is restricted to two lithologies; homogenous and banded muds, representing lake low-stands, reduced primary productivity/preservation and a well-ventilated water column. Although lake level changes occurred in the past, the water depth of the coring site – today at 350 m – unlikely fell below 200 m.

SEM and thin section analyses of the as yet enigmatic encrustations show two generations of aragonite crystals; larger (10 – 20 mm), columnar to blocky ones (inside the closed valves) and a magnitude smaller (1 – 2 mm), columnar ones (outside the valves) intercalated with clay minerals and probably organic matter. The isotopic composition of encrusted valves contrasts that of inorganic carbonates precipitating in the water column; heavier $\delta^{18}O$ supports formation in bottom water, heavier $\delta^{13}C$ is likely related to microbial activity, however, the nature of this relation is yet unclear. Encrusted valves are often articulated but display different stages of opening. As ostracod valves usually disarticulate within hours to days after the animal's demise, semi-open valves suggest that the encrustation process was – in geological terms – extremely rapid.

Our finding calls for care and attention analyzing biogenic carbonates. The episodic and faciesbound occurrence suggests that encrustation is ultimately controlled by environmental factors. The ongoing study aims at revealing the mechanism of this process.

DISENTANGLING BULK CARBONATE LACUSTRINE STABLE ISOTOPE RECORDS: THE LAKE VAN EXAMPLE

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Oxygen and carbon isotope ($\delta^{18}O$ and $\delta^{13}C$) analysis of carbonates is a commonly applied and powerful proxy in lacustrine palaeoclimatology. Bulk carbonate is the typical target material for isotope analysis, as it is believed to, in absence of detrital components, mainly represent inorganic carbonates precipitated in the epilimnion. In case of terminal and alkaline Lake Van, the interpretation of the $\delta^{18}O$ and $\delta^{13}C$ signals of bulk carbonates, is in comparison to other proxies far from straightforward when relying on traditional interpretative approaches. Consequently, we use a component-specific approach and study the mineralogical and geochemical properties of particles forming Lake Van bulk sediments. Special emphasis is bestowed upon comparing isotopic signals of the various carbonate archives of Lake Van (primary inorganic and biogenic and diagenetic) and their respective roles as proxies for palaeohydrology (e.g., palaeosalinity). Samples investigated here cover the last glacial/interglacial period. Inorganic (< 63 mm) and biogenic (> 63 mm) carbonates were isolated by wet-sieving and analysed by means of XRD, SEM and isotope mass spectrometry. High-resolution mineralogical analysis of the inorganic fraction revealed variable amounts of aragonite and calcite as well as non-stoichiometric (calcian) dolomite. However, even after excluding episodic diagenetic dolomite-bearing samples, interpretations of the primary aragonite/calcite $\delta^{18}O$ and $\delta^{13}C$ signals remain challenging. Elevated $\delta^{18}O$ values appear, for example, in both cold arid periods such as the Younger Dryas and in warm wet periods such as the Last Interglacial (MIS 5e). To resolve this inconsistency, we compared the concentration of aragonite relative to coeval calcite with the inorganic primary $\delta^{18}O$ and $\delta^{13}C$ signal. It appears that aragonite is enriched in ^{18}O and ^{13}C in comparison to calcite. Nevertheless, the differences in aragonite-water and calcite-water fractionation factors are minor, and alone insufficient in explaining changes observed in amplitude of the $\delta^{18}O$ and $\delta^{13}C$ signals in the Lake Van profile. It seems likely, that aragonite and calcite particles forming the bulk sediment precipitated under different geochemical conditions. This is of particular importance as many studies account only for differences in isotopic fractionation between aragonite and calcite ignoring processes which favour the precipitating polymorph. Here we investigate the role of seasonality as a possible influence on the distinct isotopic signals of these surface water carbonates. We also utilise the advantage of an independent benthic carbonate archive (ostracod valves of the genus *Limnocythere*), which allows us to compare surface and bottom water signals. Set in a wider context, our findings call for caution when using bulk and/or inorganic carbonates as indicator of past hydrological changes. Disentangling the bulk record, though time-consuming, allows a much more sophisticated approach to study palaeohydrology and avoids misinterpretations based on bulk archives.

THE LATE ORDOVICIAN PRE-GLACIAL PLATFORM IN EASTERN ANTI-ATLAS (MOROCCO)

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The Late Ordovician sedimentary systems in the Eastern Anti-Atlas of Morocco record the evolution of the north Gondwana platform prior to the Hirnantian glacial event. This platform is essentially characterized by siliciclastic deposits that derived from de West African Craton. Minor carbonate systems develop during specific periods.

This study based on facies analysis and sequence stratigraphic correlations shows the coexistence of two sedimentary systems during the preglacial Ordovician period. These two deposits systems had a complex spatial and temporal distribution. A large deltaic system extended on the north-eastern part of the Anti-Atlas and was widespread during regressive periods. On an another hand, a storm dominated system was developed in the southern of the eastern Anti-Atlas and was more extensive during the transgressive periods. The deltaic system was fluvial dominated with minor tidal influence. Major sea-level drops are recorded by deep incisions on the continental shelf. These significant erosional features were filled by high-energy unidirectional flows including a clear suspended load component. An interesting result is the regional polarity from E/NE to W/SW of the deltaic system in this part of the wide north-gondwana platform. This polarity is different from the rest of the northern Gondwana platform.

During the Late Ordovician, the sedimentation on this relatively flat siliciclastic platform was controlled by regional tectonic movements and mainly by eustatic sea level variations, being sometimes of high-amplitude in this “pre-glacial” context.

The Darriwilian is characterized by differential subsidence, between the north and the south of the eastern Anti-Atlas, due to active tectonics, while, Sandbian-Katian show a low rate of subsidence (x10m/Ma) in the line of intracratonic basin.

Major erosion surfaces have been recognized during Late Katian, prior to the real Hirnantian glaciation. But contrary to what is classicaly mapped and described, the Hirnantian deposits are rather well preserved in the Eastern Anti-Atlas into deep incisions. They are characterized by chaotic conglomeratic facies and associated gravity flow deposits. Cool-water carbonates are also preserved in specific domain and periods (Erfoud). The Eastern Anti-Atlas represents a particularly original and interesting domain to understand the complex palaeogeography of the north-gondwanian platform prior to the Latest Ordovician glaciation.

EARLY KINEMATIC HISTORY OF THE SE BASIN OF FRANCE AND INJECTION TRIGGERING MECHANISMS INFERRED FROM MICROTECTONIC AND AMS ANALYSES. EXAMPLE OF THE APTO-ALBIAN BLUE MARLS FORMATION, SISTERON (FRANCE)

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Understanding the way fracture networks evolve in space and time in low-permeability rocks is required in several applied problems. The turbiditic system of the SE Basin of France is associated with injectites that constitute markers of early deformation in the Blue Marls formation. It thus offers a unique opportunity to characterize the onset dynamics and evolution through time of such a 3D fracture network into low permeability rocks and to assess the early stages of deformation in the Alpine Foreland. This study explores the relative timing between (i) Blue Marls deposition, (ii) hostrock deformation, (iii) sand injection into fractures and (iv) regional changes in paleostresses and folding dynamics, thanks to microtectonic and magnetic fabric (Anisotropy of Magnetic Susceptibility) analyses in both the hostrock and injectites.

These two coupled studies put forward that the hostrock was submitted to a complex kinematic history. Six successive stress regimes were recorded in the hostrock from N/S extension to a series of NW/ SE to NE/SW compressions responsible for onset of first strike slip and finally reverse faulting. N150-N160 layer parallel shortening, put forward by the magnetic fabric, is consistent with the last compressional event triggering reverse faulting. Extension and strike slip sat on prior to folding, reverse faulting syn to post folding. The mechanical behavior of injectites seems decoupled from the hostrock, as fracturing recorded in both structures is completely different and geometry of fractures recorded in injectites totally depends on geometry of the injectite. Injection, probably triggered in several pulses, was synchronous with a N/S compression responsible for strike-slip faulting in the study area. This compression persisted after cementation of injections triggered by the first pulse.

The AMS signal in injections is more characteristic of hydrodynamic processes at the time injection took place than neither compaction nor tectonics.

UNRAVELLING TECTONO-STRATIGRAPHIC SIGNALS IN AN UPPER EOCENE ALLUVIAL SUCCESSION: LA POBLA DE SEGUR BASIN (SOUTH-CENTRAL PYRENEES, SPAIN)

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The quantification of sediment budgets from sedimentary basin analysis offers the opportunity to constrain the denudation and production of sediments in erosional landscapes, their transfer and storage throughout the alluvial system, and their eventual partitioning within the different segments of the depositional profile. This holistic source-to-Sink approach also provides insights on the sedimentary response to external forcing (e.g., Milankovitch cycles, eustasy variations, climate change and tectonics), but requires an advanced understanding of all the components of the sediment routing system, and particularly of the propagation of the sediment flux signal and its expression in terms of sedimentary facies and architectures.

The Upper Eocene Ermita Allogroup (south-central Pyrenees, Spain) is a conglomeratic fan-delta system, which prograded into a shallow lacustrine environment, and therefore offers an excellent example to test sediment mass balance reconstructions due to its semi-endoreic nature. It was deposited within La Pobla de Segur Basin, an intramontane basin located in the hangingwall of an Upper Cretaceous thrust sheet (Bòixols), and bounded to the north by a backthrust structure (Morreres), a passive roof thrust of the Pyrenean axial zone. Tectonics constantly controlled the pattern of sedimentation, leaving a complex record of regional unconformities, tilted blocks, paleocurrent patterns and clast distributions. The Allogroup is up to 200 m thick and covers an area of around 50 km^2. Excellent outcrops allow a three-dimensional study of the succession, from its most proximal alluvial reaches to its distal, deltaic and lacustrine portions.

The Allogroup is composed of three major pulses, or sequences (each 50-100 m thick), which are associated with phases of alluvial fan progradation and retreat. Progradation of coarse alluvial deposits occurs abruptly over flood basin siltstones. The sharp, erosional contact can be followed down depositional dip for 3-4 km; in the most distal portion this unconformity becomes a conformable surface underlying mouth bar and delta front sediments. The architecture of each progradational package is characterized by stacked, sharply based upward-fining units (6-20 m thick) of coarse alluvial conglomerates overlain by floodbasin siltstones. Their stacking pattern reveals an initial progradational interval followed by an aggradational central portion and a retrogradational trend, particularly well developed in the uppermost part.

Volume partitioning of conglomerate and floodbasin deposits progressively decreases up-section. The retreat of the alluvial/fan-deltas is marked by widespread floodbasin and lacustrine sedimentation, recorded up-fan by extensive paleosoils. The three higher-order sequences of the Ermita Allogroup progressively backstep towards the northern margin of the basin, superimposed to an overall retrogradational trend. The relative base-level fluctuations (valley floor or lacustrine surface) and the general retrogradational geometry here recorded are believed to represent the response of the tectonic loading induced by the emplacement of a deep thrust in the antiformal structure in the northern margin of the basin.

DEPOSITIONAL ENVIRONMENT OF MIDDLE JURASSIC SHIMENGOU FORMATION IN NORTHERN QAIDAM BASIN, NORTHWEST CHINA: IMPLICATIONS FOR OIL SHALE AND COAL ACCUMULATION

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The Qaidam Basin is the third-largest inland basin of China, and covers approximately 250,000 km^2. It has attracted attention because of abundant salt, natural gas and coal resources, and it is the seventh largest oil shale-bearing basin in China with total Middle Jurassic oil shale resources of 16.8 billion tons. Two oil shale sequences (equal to third-order sequence) in the Middle Jurassic Shimengou Formation in Yuqia area, northern Qaidam Basin in Northwest China were evaluated based on geochemical and industrial analysis. The characteristics and accumulation conditions of oil shale in the lower Coalbearing Member (J2sh1) and upper Shale Member (J2sh2) are different. J2sh1 oil shale developed in TST and HST of sequence I, the oil shale with high total organic carbon content derived from terrigenous organic matter, and is of medium-high oil yield, low ash content, low moisture, and low-medium calorific value and sulfur content, and the higher TOC value, the higher quality of oil shale. J2sh2 oil shale developed in the bottom of TST of sequence II with medium total organic carbon content derived from alginite and bituminite, and is characterized by low-medium oil yield, high ash content, and low moisture, calorific value and sulfur content. J2sh1 oil shale has much higher content of carbonate, but lower content of clay minerals than J2sh2 oil shale. J2sh1 oil shale intercalated with coal was deposited in a limnic environment under a varied climate from hot-humid to warm-humid, whereas J2sh2 oil shale was deposited in a semi-deep and deep lake environment under a stable warm-humid climate. Climatic conditions may have controlled the quality, distribution and thickness of oil shale by influencing the origin of organic matter and sedimentary environment. High paleoproductivity in J2sh2 (or high terrigenous detrital matter input in J2sh1) and strong water salinity stratification is responsible for the accumulation of high-quality oil shale.

RESERVOIR CHARACTERISTICS AND EVALUATION OF TIGHT SANDSTONE OIL RESERVOIR IN CHANG 7-CHANG 8 MEMBER OF JINGHE OILFIELD

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The Jinghe oilfield is located at the southern part of the Ordos basin. Frequently sandbody changes, tight sandstone reservoirs and strong heterogeneity have become primary problems in exploration and development of Chang 7-Chang 8 oil members in Yanchang Formation. Sedimentary system types, characteristics and spatial distribution of Chang 7-Chang 8 oil members in the Yanchang formation in the Jinghe oilfield were discussed in this paper to grasp the distribution of sandbodies and forecast favorable reservoir facies of the low permeability sandstone. Based on previous studies data, core observation and laboratory test, this paper discuss the diagenesis of reservoirs and predict the favorable reservoir strata and favorable reservoir facies belt. Research shows that distribution of sandstone was controlled by sedimentary facies. Sandstones of Chang 8 oil members deposited in shallow-water delta front. Gravity flows deposition system were widely developed in Chang 7 oil members under the background of deep lake and scale of sandstone were changeable. Main lithology of the reservoir is arkose and feldspar lithic sandstone. Compaction is one of the main factor of tight sandstone reservoirs in the study area, and intergranular pore is destroyed by cementation. Secondary pore corrosion caused by the reservoir has played an important role in improving reservoir properties.

The distribution of reservoirs is predominated by sedimentary microfacies, reservoir physical property and heterogeneity. Favorable reservoir mainly develops in underwater distributary channel, mouth bar and gravity-flow channel. On the longitudinal in the Chang 8 oil members and in the plane is the northeast part of Jinghe oilfield.

DIAGENESIS AND RESERVOIR QUALITY OF THE YANCHANG FORMATION TIGHT SANDSTONE IN BINCHANG AREA, CHINA

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The Lower Triassic Yanchang Formation in the southwestern Ordos Basin is the typical tight sandstone in China. For effective reservoir exploration and oil production, the reservoir quality and densification mechanism must be studied first. In this paper, the tight sandstones are studied by field study, core and thin section observation, fluorescent thin section observation, SEM, cathodoluminescence study, electron probing analysis and quantitative determination of reservoir properties. The result shows that the study area develop delta front deposit, and subaqueous distributary channel sandstones are fine reservoir. The sandstone are mostly feldspathic litharenites and lithic arkoses, which are characterized by low compositional maturity and relatively high textural mature. The reservoir properties are quite poor, with low porosity (average 6.4%) and permeability (average 0.362 mD), small pore-throat radius (average 0.316 μm), high displacement pressure (average 5.86 MPa) and median pressure (average 33.48 MPa). The main types of pores in the tight sandstone are secondary dissolution pores and residual intergranular pores. Micronano-sized throat is the main factor of restricting the quality of the reservoir. Quantitative statistical data reveals that three stages of the compaction (the porosity is reduced by 12%-15%, 2%-3% and 5%-8% respectively) is the key factor for the sandstone densification. The 3 stages carbonate cementation and the siliceous cementation reduced the porosity by 5%-10% and 2% respectively. Petroleum asphalt occupies a small amount of pores. However, the average content of the authigenic chlorite mainly present in the form of pore-lining cement (chlorite rim) is 1.5%-2.5%, it has a positive effect on the preservation of primary pores by inhibiting the quartz cementation, contributed 3% of the pores. The rate of enhanced porosity of the reservoir by feldspar dissolution is 0.5%-2%. The main diagenesis of increasing reservoir porosity were dissolution and fracturing, increasing the porosity by5%-6% and 1.5% respectively. In addition, the three stages of oil and gas invasion improved the reservoir physical properties, and further enhanced the reservoir heterogeneity.

THE SCHISTES À BLOCS FM: PHOTOGRAMMETRY AND 3D MODELLING OF A WORLD-CLASS EXAMPLE OF A MUD-FILLED CANYON

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The Schistes à blocs Fm is the ultimate member of the Tertiary succession infilling the southern alpine foredeep basin in SE France. Since their introduction, and because of their location below the Autapie nappe, the *Schistes à blocs* were considered as an olistostrome, i.e. a tectono-sedimentary unit linked to the nappe emplacement. However, repeated observations demonstrated that they are separated from the underlying *Grès d'Annot* Fm by a major erosional surface. The surface is strongly indented with steep slope angles and deeply cuts, up to 500 m, into the sandy Priabonian turbidites; it is then sealed and infilled by the *Schistes à blocs*. The processes of formation and the origin of the erosional surface are still questioned. The hypothesis tested in this project is the formation of a canyon, then filled by the *Schistes à blocs* Fm. A 3D model will help us to understand its dimensions and orientation, but also to visualize the infill architecture.

Our work focused on the lower part of the Schistes à blocs Fm of the Bonette-Restefond area. Eighteen lithological sections, 20 to 100 m thick, were acquired and completed by dip and strike measurements of the erosional surface. The internal architecture of the infilling is quite complex, consisting of silty mud turbidite deposits, debrites with clasts of various composition (sandstone and carbonate) and sizes (cm to pluri-metric), olistoliths and slumped intervals. In addition to the classical field observations, a drone photogrammetric survey of the area was performed, allowing a 3D gridding of the incision and the modelling of the infilling.

The base of the infilling consists of a 10 m thick unit with alternating silty to very-fine sand turbidites coming from N320E and hemipelagites. The second unit is 40 m thick on average and consists of slumps and/or debrites. The later are composed of pluri decimetric sandstone clasts which coarsen upward up to a meter. These deposits are probably related to landsliding and gravity processes affecting the steep erosional surface. The third unit is up to 50 m thick and consists of superimposed debris flow deposits. Debrites are composed of pluri decimetric clasts of various origins but the carbonate clasts are more abundant upward. In some case, only carbonate clasts are obserbed. The third unit starts with basal pluri-metric to decametric carbonate olistoliths overlaid with alternating debrites and olistolisths. The remobilized deposits incorporated in both debris flows and olistoliths belong to older Tethyan series such as Triassic and Liassic carbonates which should have been exposed at the sea floor on local highs in the more internal part of the Alps but before the nappe emplacement.

The 3D reconstruction of the erosional surface mimics an east-west-trending canyon morphology located under the La Bonette Massif. The canyon was then infilled with a first phase of hemipelagic sedimentation together with turbidite events, a second phase of collapses affecting the canyon flanks, and a final phase strongly influenced by the inputs coming from the front of the nappe before the emplacement of the olistostrome.

SYNCHRONOUS CARBON-ISOTOPE EVENTS DURING THE LOWER PLIENSBACHIAN ALONG THE NORTHERN AND SOUTHERN TETHYAN MARGINS

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Preceding Toarcian events (T-OAE, Pl-To), Pliensbachian paleoenvironments ascribed to a broadly greenhouse climate were punctuated by several positive and negative carbon-isotop eexcursions (CIEs), with episodes of enhanced organic matter burial and alternating warm/humid vs cool/arid climate conditions. In order to 1) complete existing data mainly from the northern Tethyan margin, 2) test the global nature of these events, and 3) define the precise stratigraphy of CIEs, deposits from the southern Tethyan margin (Central High-Atlas, Morocco) were investigated and compared with new data from the northern Paris Basin (Montcornet core) and the French Alps (Serre-Ponçon section). High-resolution carbon-isotope chemostratigraphy ($\delta^{13}C_{org}$ and $\delta^{13}C_{carb}$) was applied, using a well-constrained biostratigraphic framework based on ammonites for the upper Sinemurian – Early-Late Pliensbachian (*Margaritatus* Zone) interval. The global response of the carbon-isotope signal is highlighted through correlations between northern and southern Tethyan domains, based on precise biostratigraphic calibration. Everywhere, a clear negative carbon isotope excursion (-2‰) from $\delta^{13}C_{org}$ and $\delta^{13}C_{carb}$ is recorded from the end of the Sinemurian (*Raricostatum* Zone) to the end of the Lower Pliensbachian (base of the *Ibex* Zone), linked to the previously described SPBE (Sinemurian-Pliensbachian Boundary Event) recorded in western European basins, with a progressive recovery during the *Valdani* Subzone (*Ibex* Zone). Later, a double positive CIE (+1‰) occurred in the *Ibex/Davoei* zone interval, with maxima recorded during the *Luridum* Subzone (*Ibex* Zone) and the *Figulinum* Subzone (*Davoei* Zone). Paired $\delta^{13}C_{org}$ and $\delta^{13}C_{carb}$ proxies indicate that pCO_2 increased during the *Ibex* Zone, when black shales have been recognized as occurring in some basins. This increase in pCO_2, following 1) the SPBE, whose origin could be linked to CAMP volcanism or hydrothermal activity, and 2) a cool event starting at the end of the *Jamesoni* Zone, may have favored both the increase in temperature observed during the *Ibex/Davoei* interval and an increase in runoff conditions, explaining the positive carbon excursion recorded during this period.

NEW INSIGHTS INTO THE SEQUENCE STRATIGRAPHIC MODEL OF THE NORTHERN GULF OF CADIZ CONTINENTAL MARGIN THROUGH CORRELATION WITH AND INTEGRATION OF IODP EXP. 339 SITES U1386 & U1387

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The continental margin of the northern Gulf of Cadiz (SW Iberia) constitutes an interesting field laboratory to study the (inter)action of downslope (gravitational), alongslope (bottom current-related) and tectonic processes, in combination with variations in climate, sea-level and sediment supply. An extensive contourite depositional system (CDS) has developed on the middle-to-upper slope under the action of the Mediterranean Outflow Water (MOW) during the Pliocene and Quaternary. In the northern part of the CDS, the upper core of the MOW has generated a set of mounded and sheeted sediment drifts, of which the FaroAlbufeira drift was drilled during IODP Expedition 339 (sites U1386 and U1387). The seismic stratigraphic analysis of the Faro-Albufeira drift reveals Quaternary depositional sequences of 3rd and 4th order (respectively 1-2 Myr and 0.1 Myr duration), with internal subunits exhibiting basal transparent acoustic facies, grading upward into high-reflectivity facies capped by an erosional surface. The northern Gulf of Cadiz shelf, on the other hand, has been the subject of a range of sequence stratigraphic studies, resulting in the tentative definition of two 4th order (100 kyr) depositional sequences on the shelf section in front of the Guadiana river. These sequences are inferred to be asymmetric, because they are dominated by regressive-to-lowstand deposition, and composite, since they are internally composed of higher-frequency sequences presumably corresponding to 20 kyr cycles. However, this sequence stratigraphic interpretation is not constrained through direct dating. Recent surveys acquired high-resolution single-channel seismic reflection sparker profiles that correlate sites U1386 and U1387 of the Faro-Albufeira drift with the continental shelf where the sequence stratigraphic framework was originally developed. This provides an excellent opportunity to verify the validity of the actual model, and to expand it by integrating the middle/upper slope contourites. In this study, the correlation is focused on the last glacial-interglacial cycle (MIS 6 – present), because this interval is not affected by loss of amplitude of reflections at depth and multiple reflections. The reflection corresponding to MIS 6 (as inferred through the site-seismic tie) could be correlated from the middle slope to the shelf. Notably, this surface appears to be located much closer to the shelf-edge than suggested in the sequence stratigraphic model to date, and is truncated by the MIS 2 unconformity. This implies that the shelf sedimentary record is older than proposed before, and that the hypotheses regarding the climatic cyclicities controlling the shelf architecture need to be revised. As a first step in this revision, the MIS 2 and MIS 6 surfaces were mapped on seismic reflection profiles in the slope-to shelf transition, to redefine the geometry and position of the depositional sequence corresponding to the last glacial-interglacial cycle. The presented data offer new perspectives and research possibilities regarding the understanding of: (i) high-resolution (Quaternary) sequence stratigraphy on modern continental shelves worldwide; (ii) the local stratigraphy of the Gulf of Cadiz and the shelf-slope connection in a source-to-Sink perspective, as high sedimentation rates (> 100 cm/kyr) determined during IODP Exp. 339 on the slope could indicate a very effective sediment flux from the shelf.

CARBONATE MINERAL SPECIES CHARACTERIZING DEPOSITIONAL ENVIRONMENTS IN A SYSTEM LINKING TRAVERTINE TO MICROBIALITE MOUNDS, EARLY GREAT SALT LAKE, LAKESIDE UTAH

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Following the nearly 300 m fall of lake level from Lake Bonneville to the Great Salt Lake between 18000 and 13000 BP, alkaline lake margin springs deposited travertine and promoted microbialite reef growth along the nearby lake shoreline. Three carbonate mineral species formed separately in the depositional system. Aragonite, intermediate magnesium calcite (IMC) and non-stoichiometric (NS) dolomite were studied by optical and CL microscopy, XRD and SEM-EDS point analysis and element mapping.

Onshore travertines at Lakeside, fed from a fractured high-calcium Mississippian Great Blue Limestone aquifer, as well as beach aprons fed from groundwater, are characterized by clotted and acicular aragonite. Flank terracettes on lake-margin travertine mounds display vertical dropwalls built by clotted shrubs during cycles of rising lake level, which followed lake level fall and desiccation. The shrubs and their radial fibrous sparcements are composed of IMC calcite. Fracture vent deposits in the mound were initially aragonitic. But these (as well as grainy lake sediments) were then pervasively dolomitised in the lacustrine environment. Shore-parallel reefs of cm to m-scale microbialite mounds were constructed from NS dolomicrite. A last ubiquitous lacustrine cement of round-faced NS dolomite indicates flooding of the whole travertine to lake margin profile. Smooth round-surfaced crystallite aggregates to round-faced crystals of NS dolomite form isopachous rim cements, and fill part of the pore space, even inside micritic aragonite clots. This NS dolomite is found passively coating earlier travertine and lacustrine sediments.

Cyclic variations in lake level caused layering in deposits at the shoreline, with superposition of dolomite phases on clotted aragonite, or vice versa, whereas longer-term submersion or exposure allowed one or the other mineral types to predominate towards the higher and lower ends of the depositional profile at Lakeside.

Microbial mediation of clotted and shrubby fabrics, although most likely, has yet to be proven here. Round faces of dolomite crystals and crystallite aggregates indicate development in lake water that contained high amounts of organic matter. The chemical environment must clearly have changed down the depositional profile from the highly alkaline springs to the saline lake. Microbial populations probably varied between the warm subaerial spring communities (supporting steep local temperature gradients) and those in the more stable ambient temperatures of the lake water. The relationships between the physical and chemical environments, the associated microbial communities, and their signature minerals should provide direct confirmation for what is at present circumstantial evidence for microbial mediation.

RECENT FLUVIAL INPUT TO THE LAKE VAN AND ITS RELATION TO LACUSTRINE SEDIMENTS; A PALAEOCLIMATOLOGICAL ASSESSMENT

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Lake Van is the world's largest soda lake by area and the world's fourth largest hydrological closed lake by volume (3570 km^2 and 607 km^3). Lake Van is situated in a tectonically active area and surrounded by active volcanoes on a high plateau in Eastern Anatolia. The basin has the continental climate. Besides to learn about the geological history of Lake Van, it is also important to understand recent detrital load of tributary rivers and its relation with lake archives. Geology and climate are the main factors to determine the detrital load of tributary rivers and water chemistry as well as the type of lake sediment.

The goal of this work is to find seasonal differences (spring and fall) on the detrial load of rivers which discharged into the lake and to find its relations with lacustrine archives. With this aim, seasonal sediment sampling was done on the Karasu River from the east part of Lake and Karmuç River from the northwest part of Lake Van. At the same time, sediment coring was done in Lake Van. Cores location is also closed to the river mouths. Mineralogical (XRD, smear slides) and geochemical (TOC/TIC) analysis of the river sediments showed that the Rivers have the same mineralogical composition (quartz, calcite, plagioclase, illite, kaolinite). Calcite, illite, kaolinite minerals decrease during spring and increase during the fall season. TIC rate is increasing during the fall season, and this information supported that calcite is mainly abundant during the fall season in the river bed. TOC increasing during the spring season and shows that biological activity is started in spring time.

XRF records are used to find detrital rich layers and K, Ti and Fe elements are selected because they originated from weathering processes in the catchment area. The mineralogical analysis was done with XRD technique to find which minerals are in detrital rich layers. Using Pb210 data, sedimentation rate is calculated. Lithological, geochemical (XRF) and mineralogical (XRD) analysis of short sediment cores showed that sedimentation rate is different. Detrital mineral rich layers formed during high precipitation terms and the carbonate-rich layer formed during warm and dry terms. In this context, compared the data from lake and rivers they supported each other. On the basis of chronologic, geochemical and mineralogical data of the short cores showed environmental conditions is similar last 150 years. Between 150 – 370 BP the there is more detrital rich layer is found. This means the climate is relatively wet and cold and this may result from Little Ice Age (1650-1950 A.D.) at the Nothern Hemisphere.

LATE HOLOCENE CLIMATE CHANGES OF VARVED SEDIMENTS OF LAKE ERÇEK, EASTERN TURKEY: A GEOCHEMICAL APPROACH

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Climate changes have significant economic and social consequences for the communities during the centuries. Climate models are intended to simulate the evolution of climate change. Paleoenvironmental data obtained from lake archives is the critical key to getting realistic models. High-resolution analyses of varved sediment samples taken from the lakes can be used to comment on past climate changes because varved sediments allow investigating seasonal variability for to understand the long term environmental pattern.

Lake Erçek is situated on a high plateau in Eastern Anatolia (east of Lake Van). The area of the lake is about 106 km^2, and the lake level at present is 1809 m above sea level. The maximum water depth is about 36 m, and the average depth is 18.45 m. Three climate systems (Monsoon System, Midlatitude Subtropical High-Pressure System, North Atlantic and Siberian High-Pressure System) affects the Lake Erçek region, where a continental climate (cold and wet winters, warm and dry summers) prevail. Detailed geochemical examination of the varved sediments of Lake Erçek was carried out. The geochemistry of bottom sediments was determined by XRF and TOC-TIC method. The ^{137}Cs-^{210}Pb method and the varve counting were used to obtain the age model of the cores, and the ^{14}C dating continues.

The geochemical series obtained by calibration of historical meteorological data have been converted into climate units. In the last millennium, the differences in climate have been reconstructed with the annual time resolution. According to this, it is possible to reveal and correlate the climate changes for the last 700-750 years for Lake Erçek.

According to preliminary results obtained from these ongoing studies, it has been observed that sediments of Lake Erçek have regional responses to environmental changes and it is possible to explain it with the annual mean air temperature.

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CALCITE CEMENTATION ALONG AN OIL-WATER CONTACT, MIDDLE EAST

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Calcite cementation in carbonate reservoirs obstructs porosity and alters reservoir quality. However, the distribution of cements is commonly heterogeneous, as certain areas of reservoirs appear more cemented and less porous than others. Investigating the processes leading to cementation across individual reservoirs is therefore critical as it may improve the spatial prediction of reservoir properties.

This study documents an example of peculiar calcite cementation in a giant oil reservoir (Lower Cretaceous, Middle East). The most abundant cement phase is coarsely crystalline and occupies secondary porosity such as moulds and fractures, mostly near the top of the reservoir. The cement phases exhibit a dull and sector-zoned luminescence. Most oxygen and carbon isotopic values are in the range of that of the host rock, i.e. -3 to -6 and +2 to +7 (‰ vs. VPDB), respectively. The petrographic characteristics of the cement phase, as well as its isotopic signature, suggest that precipitation occurred late during burial in rock-buffered conditions at low temperatures (< 60°C). However, numerous samples collected near the top of the reservoir yielded abnormally high $\delta^{13}C$ values (> +10 ‰). Such $\delta^{13}C$ values are typical of methanogenic bacterial degradation of organic matter at low temperature.

This study proposes that cementation occurred in presence of hydrocarbons, probably near an early oil-water contact interval located at the top of the present reservoir. Oil migration is believed to have begun in the Late Tertiary when the Arabian Plate tilted northwards, forcing hydrocarbons to move to the south into Cretaceous strata at a depth of 600-700 m. The emplacement of oils into an active freshwater aquifer promoted the development of bacterial communities which degraded oils. This in turn caused the production of bicarbonates that precipitated calcite cement in open porosity. This model has potential implications for the distribution of reservoir properties across the study area. Indeed, one can expect the initial oil-water contact that was responsible for methanogenic cementation to have extended laterally. As a result, it is likely that a cemented interval characterised by lower porosity now exists within the reservoir and negatively impacts the drainage of hydrocarbons.

SPATIAL DISTRIBUTION OF POROSITY IN NORTH SEA CHALK, DENMARK

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The Upper Cretaceous Lower Tertiary chalk constitutes an economically strategic lithology of the North Sea basin as it contains significant water and hydrocarbon reserves. Chalk consists of lithified carbonate ooze that originally deposited by pelagic rain at great water depths (> 200 m). As a result, chalk is commonly found forming laterally extensive beds of pelagic sediments. Complex stratigraphic geometries also occur and document large-scale redeposition of carbonate ooze, either by gravity or strong bottom currents.

A peculiar property of chalk is its high interparticle porosity (> 30 %), even at burial depths of several kilometres. However, the extraction of hydrocarbons and water from chalk is challenging because of the variable permeability associated with uniformly high pore volume. Studies have shown that reservoir properties of chalk vary depending on numerous factors, including the mode of deposition, microfacies, clay and silica content, maximum burial depth, as well as the diagenetic overprint. However, it is poorly understood why reservoir quality can vary significantly within a given stratigraphic unit, provided that all other properties are constant.

This ongoing study focuses on outcrop analogues in northern and eastern Denmark of the upper Maastrichtian Tor Formation, the most important chalk reservoir unit of the North Sea. Its purpose is to investigate the spatial distribution and organisation of porosity within laterally monotonous and homogenous facies units. The study combines (1) photogrammetry to reconstruct the outcrop architecture in 3D, (2) conventional plugs collected from the cliff faces for porosity-permeability measurements, as well as (3) SEM analyses of polished thin sections for microfacies and porosity analyses. Preliminary results show variable porosity and permeability at the decimetre scale between 40 to 50 % and 1 to 10 mD, even though microfacies and diagenetic overprint appear invariable. Microscopic analyses document subtle variations of grain sorting and packing, as well as the organisation of the interparticle pore system. These observations have direct implications for the prediction of reservoir quality and flow modelling in chalk reservoirs.

HOW TO MAKE AN ALKALINE LAKE? – LAKE VAN CASE STUDY

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Lake Van (Eastern Anatolia, Turkey) originated ca. 600 kyr before present and is nowadays the largest existing terminal soda lake on Earth. Members of ICDP PALEOVAN established that Lake Van originated as open lake, based on lithological change, the presence of freshwater microfossils and close-tofreshwater pH values of the pore water. Geochemical and paleontological data shown here substantiate this conclusion and give a best estimate of the time of closure. Further we provide a conceptual hydrological model for the transition to a terminal, alkaline lake. Our chosen proxy archives are inorganic and biogenic carbonates separated by wet sieving. We use the fraction > 63 µm to identify the microfossil assemblage sand to perform high-resolution oxygen and carbon isotope ($\delta^{18}O$; $\delta^{13}C$) and elemental (Mg/Ca; Sr/Ca) analyses of the fraction < 63 µm under the assumption, that carbonates present in this fraction precipitated in the water column (endogenic precipitation). The ostracod assemblage consists of three different genera (Candona spp., Loxoconcha sp., Amnicythere spp.). Candona spp. occurs in most samples the of Lake Van record (600-270 kyr) and are fresh to brackish water ostracods, while Amnicythere spp and Loxoconcha sp, both comprise brackish to saline water ostracods. The latter occur more often in sediment younger than 530 kyr and additionally Loxoconcha sp is a shallow-water species bound to plant growing in the photic zone as food supply marking an increasing salinity and lake level shallowing. Relatively low $\delta^{18}O$ and $\delta^{13}C$ values of the inorganic calcites characterise the early stage of Lake Van (600530 kyr BP) and both increase abruptly ($\delta^{18}O$: ~7‰; $\delta^{13}C$: ~4‰) after 530 kyr BP. Change in isotopic composition is accompanied by the first occurrence of aragonite. Concurrent patterns in microfossil as well as geochemical and mineralogical data show changes in the lake character towards more saline water and shallower basin at 530 ka BP. These synchronous changes in independent proxies give us strong evidence that Lake Van closed at around 530 kyr BP. The comparison with $\delta^{18}O$ data of Lake Ohrid in Macedonia suggests that a regional climate change (e.g. increased evaporation) is an unlikely cause for the transition recorded in Lake Van. The sedimentary archive does not contain evidence for increased volcanic or tectonic activity (e.g. tephra layers, deformation structures, slumping) corresponding to the changes at 530 kyr. Consequently, blocking of the outflow by a pyroclastic flow does not seem plausible. Our tentative conceptual model describes a reduction in the amount of inflow (e.g. by river diversion) resulting in a change of the hydrological balance and a lake level fall below its outlet.

PASSAGE OF THE ZANCLEAN FLOOD TO THE EAST MEDITERRANEAN SEA

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A major implication of the Messinian desiccation theory is the return of open-marine conditions via a flood at the onset of the Zanclean stage of the Pliocene Epoch. The extent, magnitude and timing of this flood are subject to debate, and most of the evidence about, and numerical modelling of this event is based on observations from the western Mediterranean Basin. In this study we present evidence for the passage of the Zanclean flood into the eastern Mediterranean Basin. We analyse academic and industry geological and geophysical data from the western Ionian Basin to identify a thick and extensive sedimentary body overlying Messinian evaporites. In view of its volume, wedgeshaped geometry and chaotic seismic character, we interpret this body as a deposit of material eroded and transported from the western to the eastern Mediterranean during the Zanclean flood. Based on the extent of this sedimentary body, the reconstructed Messinian topography and the occurrence of a unique, relict erosional canyon on the Malta Escarpment, we infer that the gateway for the flood was likely located in SE Sicily.

HETEROZOAN CARBONATES: WHEN, WHERE AND WHY ? A SYNTHESIS ON PARAMETERS CONTROLLING CARBONATE PRODUCTION AND OCCURRENCES

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In modern and Phanerozoic times, heterozoan carbonates group a large array of depositional environments from the poles to the tropics. This global review establishes the critical parameters and controlling factors of heterozoan carbonates: (i) stratigraphic and global distributional trends, (ii) oceanographic and trophic relationships, and (iii) biological and sedimentary processes. Well documented case studies (n=129) have been reviewed where facies and stratigraphic attributes were available, and environmental settings, such as oceanography, climate and paleogeography were determined. These case studies occur during specific periods of time in the sedimentary record, e.g. Late Ordovician, Early Carboniferous, Early Permian and Neogene, while they are absent during others, e.g. Triassic and Jurassic. Periods during Greenhouse to Icehouse transitions and of active thermohaline circulation are particularly conducive for heterozoan carbonates. A new classification scheme is proposed that follows global oceanographic patterns showing two main heterozoan carbonate systems: (i) a highly productive system characterized by filter-feeding biota and (ii) an oligo-mesotrophic, warm-temperate system characterized by red algal and seagrass-derived biota. On a local, platform scale, depositional profiles, which are based on (i) the source of energy for metabolic activities that allow the carbonate-producing biota to thrive and (ii) hydrodynamics and physiography of the depositional system, are proposed to implement the facies spectrum approach of James & Jones (2016).

SYN-SEDIMENTARY SUBSURFACE LIQUEFACTION AND COLLAPSE; INJECTITES, PSEUDO-CHANNELS AND PSEUDO-CLINOFORMS IN THE JURASSIC ENTRADA AND CURTIS FORMATIONS, UTAH, USA

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Intra-formational collapse features and sand injectites in the Jurassic Entrada Sandstone are linked to unusual channel-and clinoform-like features in cliff sections belonging to the overlying Curtis Formation. At first sight, large-scale features appear to represent conventional sedimentary architecture such as channel incision and clinoform development. Close inspection reveals syn-sedimentary subsurface collapse and sag of intra-Entrada Sandstone and/or Curtis Formation beds caused the features, rather than a sedimentary response to channelized transport and basin deepening.

The middle to upper Jurassic succession in eastern Utah is composed of widespread units with moderate lateral variation on a regional scale. Above the well-known Navajo Sandstone, the Page Sandstone, the Carmel Formation, the Entrada Sandstone, and the Curtis and Summerville formations follow in successive order. Recent years' field campaigns has revealed a number of intra-formational collapse features, injectites and faults within the Entrada and Curtis formations, which may be explained by liquefaction of water-laden subsurface strata at the time of collapse. The collapse features and sand-injectites in the Entrada Sandstone are contained within its upper Earthy Facies, a wet aeolian/inter-dune depositional unit with immature soil profiles. These are preserved as towering sandstone pillars in today's landscape, due to their differential cementation that resulted in increased resistance to weathering and erosion.

Intra-Curtis Formation features resemble channels and clinoforms (hence the pseudo-prefix), but formed in response to local syn-sedimentary sagging, driven by mobilization/liquefaction of older marine mud within the same unit, or by the same mechanisms as in the underlying Entrada Sandstone. A combination of the two is possible. The channel-like features do not show erosion into older beds, but appear to be passively draping a miniature sag basin. Either side of the sag feature is characterized by a dense set of 5-15 cm offset faults with several syn-sedimentary features such as small growth packages and intense climbing ripple lamination across small escarpments. Asymmetric fault geometries on opposing sides indicate slight lateral tectonic rafting during development. A clinoform-like succession resembles sedimentary architecture normally associated with delta mouth-bar deposition, but is actually a series of faulted sand-and mudstone beds with sediment transport "upstream", which appears to represent a larger-scale version of the aforementioned channel-like feature. Both depositional environments are interpreted to represent sub-to intertidal sand flats.

On-going efforts to characterize and date cement in the collapse breccia is expected to improve constraints on timing of events, and thus strengthen or contradict the working hypothesis that suggests linked mechanisms.

VARIATIONS IN THE MINERAL COMPOSITION OF THE GABONESE MARGIN SEDIMENTS AND THEIR IMPACT ON ORGANIC MATTER CONTENT

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Oceanic margin sediments are typically composed a complex mixture of biogenic autochthonous particles and detrital minerals resulting from the erosion of the adjacent continents. Among these detrital minerals, the different clay species constitute the main component in the fine-grained hemipelagite deposits and it has been proven that these minerals are partly responsible for the high organic car-bon content usually recorded in these locations. The present study focuses on the Gabonese margin and aims at better understanding the distribution of the different minerals across the margin through the past 200,000 years and to determine the influence of the different factors climate, sediments sources, transport pathways, minerals differential settling on this repartition. We also estimated the influence of the clay minerals variations on the organic content of these sediments. The work combines elemental (XRF, TOC), isotopic ($\delta^{13}C$), minerals (DRX) and observational (TEM) data recorded on a 12 m long sediment core. The sediments are composed mainly of calcium carbonate, quartz and clay minerals. Among the clay minerals, smectite is largely dominant followed by kaolinite and in lesser quantities illite. We noticed on the different records a clear glacial/interglacial pattern with glacial stages being marked by a rise of the terrigenous accumulation rate, a relative increase of the kaolinite and illite content compared to smectite and a shift towards higher smectite crystallinity. We identified that the sea-level variations were in this specific area the main driving force for these changes and that climate influence was certainly much reduced. The higher proportion of the terrigenous minerals content during lowstands is due to the seaward displacement of the coastline that allowed the contribution of the exposed shelf area to the erosion process as proven by the record of some shelf specific minerals, such as clinoptilolite, in the lowstands sediments. Moreover, the fluctuations of the kaolinite relative proportion are interpreted as the result of the seaward shift of the kaolinite settling area. The TEM studies of the in situ distribution of organic matter in the sediments indicate an intimate association of smectite with organic matter: the organic matter being localized at the junction of smectite particles and certainly acting as a “glue” to form organo-clay aggregates. Carbon isotopic data indicate that the organic matter involved in such associations is specifically of marine origin. The formation of such aggregates is certainly a key factor in the preservation of marine organic matter. The overriding control of sea-level changes on the clay mineral distribution patterns will consequently greatly influence the organic matter composition of the sediments in this area.

FORMATION OF MG-ALUMINOSILICATES DURING EARLY DIAGENESIS OF CARBONATE SEDIMENTS IN THE VOLCANIC CRATER LAKE OF DZIANI DZAHA (MAYOTTE – INDIAN OCEAN)

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Authigenic silicates are increasingly reported in ancient carbonate rocks, but their origin remains poorly understood, strongly limiting paleoenvironmental interpretations. The volcanic crater lake of Dziani Dzaha in Mayotte is studied to assess the processes controlling the formation of silicates in carbonate sediments during early diagenesis.

The Dziani lake is characterized by CO_2-rich volcanic gases bubbling in three different locations, a seasonally CH_4-saturated water column due to archaeal methanogenesis and a high biologic productivity leading to organic carbon contents of up to 25wt.% in the sediments. Alkalinity of ~0.26 molal and pH values of 9 to 9.5 in the water column result in the precipitation of aragonite and hydromagnesite. Characterization of bulk samples from the first meter of the sedimentary column with X-ray powder diffraction and X-ray fluorescence spectrometry indicates a decrease of the hydromagnesite content with depth and the concurrent accumulation of a Mg-and Al-rich smectite, accounting for ~20wt.% of mineral phases at 1m deep. Concurrently, analyses of pore waters show a decrease of pH values with depth from 9 to 8.3. The clay fraction (<2 µm) was characterized with X-ray powder diffraction after ethyleneglycol and glycerol solvation, electron probe micro-analysis and measurements of cation exchange capacity as being a single phase of saponite.

To constrain the diagenetic processes at the origin of the observed mineral assemblages, we performed modeling with the reactive transport code Crunchflow, taking into account the sediment burial and the mineralization of organic matter. High pH values combined with the alteration of alkaline feldspars and clinopyroxenes from the volcanic catchment allow saponite to form and accumulate at depth. Production of CO_2 associated to microbial methanogenesis is required to account for the observed pH decrease in the porewaters, which induces hydromagnesite destabilisation at depth leaving behind a saponite-aragonite mineral assemblage. Formation of carbonate rocks associated to Mg-phyllosilicates in the Dziani Dzaha is shown to be controlled by the alteration of the basic volcanic catchment and relatively high pH values resulting from extremely active photosynthesis. The inputs of CO_2-rich volcanic gases likely fuel the massive biologic productivity, which in turn fuels archeal methanogenesis.

ALTERED VOLCANIC DEPOSITS AS BASAL FAILURE SURFACES OF SUBMARINE LANDSLIDES

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One of the main concerns regarding the development of submarine landslides is the role played by weak layers in the failure process and, in particular, their impact in terms of volume, shape and evolution of mass movements. In the present study we identified the mechanism of formation of a weak layer in the eastern margin of the Corsica Trough (northern Tyrrhenian Sea) that originated the Pianosa Slump at 42-50 kyr BP. This layer is characterized by a loose sediment structure, high moisture content, high plasticity, high compressibility and a post-peak strain softening behavior (i.e. strength loss with increasing strain). These specific mechanical and sedimentological properties are related to the presence of zeolites of analcime type with a concentration of 2-4% in the muddy sediment. Zeolites are minerals commonly formed by the alteration of volcanic rocks that were probably transported from the Tuscan magmatic province during a sea level low-stand. The influence of the zeolitic layer on slope instability was tested numerically using an elasticperfectly plastic model with an approximated strain softening approach. Modeling results show that erosive processes at the foot of the slope could create enough strain to reduce the shear strength of the zeolitic layer and focus the development of a failure surface in this layer. We conclude that the strain softening behavior of muddy zeolitic sediment plays an important role in predisposing submarine landslides on continental slopes.

MORPHOLOGICAL CONTROL OF SLOPE INSTABILITY IN CONTOURITES: A GEOTECHNICAL APPROACH

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Contourite drifts are sediment bodies formed by the action of bottom currents. They are commonly found on continental slopes and often affected by slope failure. However, the processes that control slope instability in contourite depositional systems are still not well constrained and it is not clear whether contourites present particular properties that make them more susceptible to slope failure. In this study we did a comparison of the sedimentological and geotechnical properties of contouritic and hemipelagic sediments in the Corsica Trough (Northern Tyrrhenian Sea) using Calypso piston cores and boreholes. Sedimentological and geotechnical analyses show some differences between the properties of contourites and hemipelagites. The plastered drift presents finer material, lower density and lower undrained shear strength than hemipelagites. Contourites have a higher compressibility than hemipelagites but a similar permeability. After a geomorphological and a slope stability analysis, we found that the main factor controlling the location of submarine landslides in a contouritic environment is the morphology of the drifts. Plastered drifts are convex-shaped deposits formed on continental slopes that present steep slopes in the lower part, where the factor of safety, and thus the stability, is the lowest. Moreover, erosion is common at the foot of the plastered drifts and it may trigger a submarine landslide by undercutting the slope.

EARTHQUAKE-TRIGGERED REMOBILIZATION OF SURFICIAL SLOPE SEDIMENTS IN LAKES AND OCEAN MARGINS: IDENTIFICATION AND SIGNIFICANCE

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To assess the reliability of turbidite paleoseismology, it is crucial to precisely understand and characterize the processes, in which earthquake shaking initiates sediment remobilization, transport and eventually deposition. In most studies, it is assumed that strong earthquakes trigger landslides on the slopes and the moving masses transform into turbidity currents propagating to the deep basins. By studying the composition of turbidites in Chilean lakes, we discovered that turbidites were produced by earthquake-triggered remobilization of only a thin veneer (~5 cm) of surficial slope sediments. This paradigm-shifting finding has been validated at an ocean margin, i.e. the Japan Trench, suggesting that this process may be of worldwide significance.

Here we present the first results of a multi-method approach to identify and characterize surficial remobilization in Chilean lakes and at the Japan Trench. In contrast to previous studies, we focus on the slope sedimentary sequences where we aim to detect subtle evidence of event-related surficial erosion. We compare results from i) stratigraphic correlations, ii) geochemical proxies (short-lived radionuclides, pore water geochemistry), and iii) sediment-physical proxies (CT-scans, shear strength). Moreover, we deployed a cohesive strength meter on sediment cores in order to quantify the erosion process by measuring the response of sediments to step-wise increasing bottom shear stresses exerted by a water jet. In this experiment set-up, we explore the hypothesis that differential motion between the seafloor and the inertial bottom water induce bottom shear stress acting on the surficial sediment.

Preliminary data highlight the many methodological challenges for identifying and quantifying subtle erosion events within sedimentary records. This allows us to discuss the applicability of different methods for either the lacustrine or marine realm. Especially in the latter setting, bioturbation may severely obliterate most evidence. In contrast, the laminated sediment core in a Chilean lake shows that about 5 cm of slope sediment was remobilized during the AD1960 earthquake. The cohesive strength measurements (CSM) revealed rather similar erosion thresholds for surficial sediments in most settings, which suggest that surficial remobilization may be a common process when seismic shaking is strong enough. Different calibration approaches result in threshold bottom shear stresses ranging in one order of magnitude. Therefore, new approaches need to be developed to reliably transform the CSM results, and compare them with earthquakerelated shear stresses at the sediment-water interface.

The measured erosion threshold remains rather constant with core depth in most tested settings (except for the Japan Trench). This suggests that slopes do not always need to get recharged with sediments between successive earthquakes in order to produce surficial erosion and subsequent sediment density flows. This new insight let us conclude that surficial slope sediment remobilization forms a valid mechanism that explains why turbidite paleoseismic records can be of excellent continuity and high sensitivity.

LACUSTRINE PALEOSEISMOLOGY IN THE AUSTRIAN ALPS: STRATEGIES FOR REVEALING THE RECURRENCE OF LOCAL MW5+ EARTHQUAKES AND FAR-FIELD MW8+ EVENTS

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To better understand the complexity of intra-plate earthquakes in formerly-glaciated regions, welldistributed long-term regional paleoseismic records are crucial. Lacustrine paleoseismological studies have been performed on many small and large alpine and piedmont lakes in the French, Italian and Swiss parts of the Alps, leading to some significant improvements in methodological approaches, detecting of periods of enhanced seismicity and discussion of possible paleo-earthquake scenarios. Remarkably, lakes within the Austrian Alps have not been explored yet for sedimentary evidence of past earthquakes, despite being a country with several areas of moderate seismicity and damaging historical earthquakes with epicentral seismic intensity up to IX-X. Here, we present the research strategies of two new projects on Austrian lake paleoseismology and show the preliminary results obtained on different lakes types located in different geological and morphological settings.

Carinthia (southern Austria) has been strongly shaken (intensity VI-IX) during several historical earthquakes in 1201, 1348, 1690, 1857 and 1976, of which the 1348 event may even have been the strongest historical earthquake of the Alps with an estimated Mw of ~7. We explored large lakes in Carinthia (Ossiachersee, Millstaettersee) by reflection seismics and short coring. The lake records contain multiple horizons with sublacustrine landslide deposits and turbidites, of which one level stands out due to its ubiquitous large landsliding and wide-spread in-situ fracturing of sedimentary sequences. Sediment cores in Millstaettersee reveal finely-laminated sequences highlighting the potential for high-resolution dating and core correlations. Different types of turbidites are observed on petrophysical and grainsize data, and we speculate that these signatures may help to discriminate an earthquake or flood origin for each turbidite.

We also explored the Tyrolean lakes Achensee and Hechtsee by reflection seismics and short coring. Whereas Achensee shows several large delta collapses, the Hechtsee lacks clear evidence of gravitational mass movements. However, authentic historical accounts attest that large waves occurred and inundated the shores on the 1st Nov. 1755, despite windless conditions on the lake. This seiche phenomena was believed to be a far-field result of the Mw8.5-9 earthquake offshore Portugal, the largest known earthquake in Europe. We test this hypothesis by i) multi-proxy tracing and dating of a possible seismic seiche deposit in the sedimentary record, and ii) by numerical modeling of seiches based on a high-resolution bathymetric model and comparison with seismic wave characteristics for such great far-field earthquakes.

APPLICATION OF STABLE CARBON AND OXYGEN ISOTOPES IN UNDERSTANDING THE NATURE AND SPATIAL DISTRIBUTION OF CEMENTATION IN CONTINENTAL CARBONATES

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Pleistocene travertine deposits of the Çakmak quarry (Denizli basin, Turkey) are studied as a worldwide analogue to infer the reservoir quality of dominantly subaqueous microbial carbonates. Cementation can considerably reduce porosity and permeability. The origin and timing of cementation are therefore important factors influencing reservoir properties. Stratigraphic analysis allowed the subdivision of the carbonate succession into three main sedimentological units (Unit 1, 2 and 3). The three units, with a total thickness of nearly 16 m and 400 m wide, were investigated with optical and CL microscopy coupled with micro-analysis of the stable carbon and oxygen isotopes. The former analysis indicated non-luminescent calcite cements as major diagenetic features affecting a high proportion of the three units. The CL pattern of the cements points to an early diagenetic origin and precipitation under oxic conditions. In contrast to the homogenous CL pattern, the three units show variations in their $\delta^{13}C$ and $\delta^{18}O$ values. Unit 1 shows $\delta^{13}C$ and $\delta^{18}O$ values ranging between 0.8 and 3.7‰ and -7.9 to -5.8‰, respectively. Unit 2 values fall within ranges of 0.2 to 2.1‰ for $\delta^{13}C$ and -7.6 to -5.7‰ for $\delta^{18}O$. Unit 3 displays $\delta^{13}C$ and $\delta^{18}O$ values ranging between -0.36 and 1.7‰ and -8.4 to -6.7‰, respectively. In Unit 1, cements are more depleted than micrite for $\delta^{13}C$, but surprisingly more enriched values for $\delta^{18}O$. However, in Unit 2 and 3 cements display $\delta^{13}C$ and $\delta^{18}O$ values that are more depleted than micrite.

Different patterns in both $\delta^{18}O$ and $\delta^{13}C$ values in the three units suggests that the shift in isotope values was caused by changes in spring recharge, which correspond to the stratigraphic pattern. The relatively more depleted $\delta^{13}C$ and more enriched $\delta^{18}O$ values in cement rather than micrite in Unit 1 could be caused by the infiltration of low temperature fluids derived from palaeosols overlying this unit. While, in Unit 2 and 3 the more depleted $\delta^{13}C$ and $\delta^{18}O$ values could be caused by direct influence of meteoric waters. The lack of major differences in $\delta^{18}O$ values suggests that the carbonate source rock for all the three units is the same, and variations can be related to changes in groundwater level. From a reservoir point of view, the cements have reduced porosity-permeability in an early diagenetic stage, however they have also provided a framework giving the rock a higher strength that will inhibit porosity-permeability decrease during compaction.

TOARCIAN FACIES IN THE SUBBETIC (BETIC CORDILLERA, SOUTHERN SPAIN): A SYNTHESIS AND PALAEOENVIRONMENTAL RECONSTRUCTION

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The Toarcian sedimentary rocks outcrop in many areas of the Subbetic (Betic Cordillera, Southern Spain). The Subbetic represents the distal Mesozoic deposits of the South Iberian Palaeomargin (Western Tethys). This is a key area due to its location, close to the Gondwana Palaeomargin and affected by singular ocean dynamics occurring in the Hispanic Corridor, the connection between Western Tethys and the ProtoAtlantic seaway, at an approximate palaeolatitude of 20°N in the Toarcian. The physiography of this palaeomargin was irregular due to severe Jurassic intercontinental rifting during the Pliensbachian, with two major trough (Intermediate Domain and Median Subbetic) and swell areas (External and Internal Subbetic). The thickness of Toarcian sections in the representative Zegrí and Baños formations (Domerian-Aalenian in age) varies from only a few to more than 200 metres. In addition, some Median Subbetic areas present submarine basalts.

This contribution offers an update about Toarcian deposits from the Subbetic, their environmental interpretation and the main outstanding questions to be addressed in the future.

Five main types of lithofacies are differentiated in the Toarcian sedimentary rocks: 1) Grey marl; 2) grey-yellow marl-marly limestone rhythmite; 3) grey-yellow limestone, locally with chert; 4) red nodular marly limestone and marl (marly "ammonitico rosso"); and 5) white and yellow laminated limestone and calcarenite. Facies 1 to 4 are interpreted as hemipelagites, deposited in shallow depths where the fairweather accumulate is mud. Facies 1 was deposited in rather depleted oxygen conditions with slightly dysoxic bottom waters but discarding completely anoxic conditions. The carbon cycle perturbation related to the Toarcian Oceanic Anoxic Event (T-OAE) is clearly recorded in facies 1 of some outcrops by the increase of total organic carbon (TOC) and redox sensitive elements, the decrease of $CaCO_3$ and the negative excursion of $\delta^{13}C$ at the base of Serpentinum Zone (Lower Toarcian). The South Iberian record of the T-OAE is synchronous respect to that described in other Tethyan margins. We emphasize that the T-OAE is recorded in this region in spite of relatively low TOC values (maximum of 1.05 wt. %). Facies 5 mainly consists of peloidal grainstone with ooids and bioclasts, with abundant shallow water foraminifera that are clearly allochthonous; these facies are interpreted as tempestites and/or internalites.

The relative palaeobathymetry of these facies is difficult to stand out. In some areas by the distribution of the reworked sediments (facies 5), there are evidences indicating deeper conditions for instance for the grey materials than for the ammonitico rosso. Nevertheless, we consider that other factors (mainly influence of emerged lands and carbonate platforms and differential subsidence by local tectonics, sediment winnowing by currents, sedimentation rates, bioturbation and diagenesis) may eventually have had more importance in the distribution of the facies types than depth. This assumption is based on evidences as the similar variation in the clay and carbonate content in the marly facies and the close space-time relations, because the five types of facies appear interlayered and sudden facies changes are observed between them.

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A SOURCE-TO-SINK APPROACH OF THE CONGO SYSTEM SINCE 200 KA. PART II: WATER AND SEDIMENT DELIVERY SIMULATED WITH HYDROTREND

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In this study, we aim to numerically quantify the evolution of water and sediment supply leaving the Congo watershed during the last 155 ka by integrating all changes in environmental conditions and to decipher the forcing parameters controlling supplies over glacial/interglacial stages. Located in equatorial Africa, the Congo River is the world's second river in term of drainage area and water discharge. The basin extends over the two hemispheres, leading to an annual homogeneous repartition of temperatures and precipitations and modest variation in intra-annual discharge. Monitored for decades, a large fluvial dataset is available for both the hydrology and sediment load. Moreover, the Quaternary Congo's offshore domain has been widely studied and abundant paleo-environmental parameters proxies were compiled from offshore cores. This abundance of data allows for accurate calibration of the numerical model HydroTrend, a climate driven hydrological transport model. HydroTrend simulates water discharge and sediment flux based on climate characteristics as well as morphology, lithology, land cover and anthropogenic factors and can be of great interest for estimation of flux inputs to stratigraphic models. HydroTrend simulations for Congo match well the present-day observed data when a significant part of the sediments is trapped in the floodplain. Long-term simulations show that environmental changes between glacial and interglacial stages account for a 30% maximum variation of sediment supply. External climatic changes (precipitations and temperatures) only account for a maximum change of 20% while induced land cover changes appear as a more significant factor; the loss of forest during colder and dryer stages enhancing sediment supply up to 30%. Globally, we highlight that peak fluxes may have occurred during a warming period, just before forests had a chance to reconquer the catchment, i.e. during deglacial periods. These results are in good agreement with the stratigraphic simulation of the deep-sea fan, applying DyonisosFlow (IFPEN) (Laurent et al., this volume, part I), even if the total average volume of sediment exported to the ocean calculated by HydroTrend is somewhat less than the observed volume of deposited sediment inferred from seismic data. Indeed, HydroTrend accurately simulates suspended sediment load, but bedload and dissolved load, which are not taken into account in this study, seem to play a non-negligible role in deep sediments distribution, as shown by the physical and chemical composition of oceanic sediments.

ORBITAL FORCING OF ORGANIC MATTER QUALITY AND QUANTITY IN A SOURCE-ROCK FORMATION: THE CASE OF THE VACA MUERTA FORMATION, TITHONIAN-VALANGINIAN, NEUQUÉN BASIN, ARGENTINA

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The Vaca Muerta Formation (Jurassic-Cretaceous transition) from the Neuquén Basin is an important petroleum source-rock formation in Argentina. Several cores from exploration wells were fully analysed. A cyclostratigraphic study was also successfully conducted, based on a set of continuous data from several neighbour cored wells. Among various variables successfully tested, the Total Organic Content (TOC), either continuously measured with the Laser Induced Pyrolysis System (LIPS) method (1 cm spacing) or derived from Rock-Eval 6 (1 m averaging window), has shown the control of orbital forcing on the variation of organic matter distribution. Moreover, and of particular interest, the integration of the Rock Eval Hydrogen Index (HI) and Oxygen Index (OI), providing useful information on the quality of the source rock, were also tested on 164 m long cores from the Lower Vaca Muerta in order to understand the climatic conditions which have favoured the deposition and preservation of organic matter in the basin. In all four signals, cyclic changes were attributed to astronomical forcing. The data shows that the main driver of the slight oxygenation change of the basin is the obliquity. We attribute this link to changes in the sea level due to fluctuations in ice coverage in the ice-house climate of the late Jurassic – early Cretaceous. Moreover, HI, OI and TOC correlate with the precession, the long and the short eccentricity. We thus suggest the following depositional scenario. With falling sea level, the connection between the Neuquén basin and the proto-Pacific gets shallower, resulting in stratification of the basin with warm fresh water supplied from the south of the basin sealing off the deeper basin. With rising sea level, the connection to the ocean gets wider and the stratifications weakens. Nutrients are mainly supplied by continental run-off from the south of the basin due to monsoonal activity during winter, which varies with the precessional cycle. Warm, hypersaline waters are in addition formed in the south-east of the basin, during the parallel formation of the sabkha deposits of the Loma Montosa Formation during summer. This would lead to the formation of a hypersaline lens in the deepest part of the basin and would thus cut it off from oxygen supply.

TURBIDITIC SEDIMENTATION INTO THE BASINS OFFSHORE LESSER ANTILLES (MARTINIQUE AND KALANINA BASINS)

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The subduction eastern margin of Lesser Antilles, especially offshore Martinique, Dominique and St-Lucie islands is characterized by many canyons and basins with various dimensions. North and South Kalanina basins are two small intra-slope basins (20 km long and 10 km large) connected to different canyons whereas the Martinique basin is the deepest basin (80 km long and 20 km large) connected to several canyons from the different islands and many intra-slope gullies.

Very high seismic profiles and four sedimentary cores were collected during the oceanographic cruise CASEIS (2016) in these basins. A detailed sedimentological study of these cores, including grain size, X-ray images, XRF core scanner data and petrographical analyses have been achieved and completed with a biostratigraphical study.

The main results show that sedimentation offshore the Martinique Island is largely dominated by turbiditic processes with centimeter –to-decimeter-thick amalgamated sequences, liquefaction and load structures or tubidites with a well-homogenized upper part. Turbidites are terrigeneous during lowstands (marine isotope stages MIS 2, 3 and 4, MIS6) whereas turbidites contain predominantly carbonated pelagic material (planktonic foraminifers and pteropods) during highstands. The turbiditic frequency is similar into the different basins whatever their depth and the high frequency of turbidites composed of pelagic material suggests that they could be co-seismic turbidites during interglacials. However, the achievement of calculation of co-seismic turbidite frequency will be underestimated because of the presence of large erosive massflow deposits both during MIS 5 and during MIS 1. A terrigeneous sandy turbidite (~80 cm thick) is observed at the top of all the cores (MIS 1), whatever their location is. It is also interpreted as an earthquake-related event.

THE ORIGIN OF NORTH GONDWANA CAMBRO-ORDOVICAIN SANDSTONES AND THEIR LINKAGE TO PAN-AFRICAN OROGENY: THE DETRITAL RUTILE SIDE OF THE STORY

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The development of a vast Cambro-Ordovician siliciclastic veneer that covers much of North Africa and Arabia and spreads thousands of kilometers into the Gondwana hinterland was a fundamental geological process that shaped Earth's surface following the transition from the Precambrian to the Cambrian. The origin of these Cambro-Ordovician sandstones and their genetic linkage to Pan-African orogens are of broad interest because of the extraordinary sand volume that was generated and because they coalesced with important global environmental changes. Previous field-based indications and detrital zircon U-Pb and Hf data showed that the quartz-rich sand was sourced from Pan-African terranes at Gondwana's hinterland to the south. We report new U-Pb data for detrital rutiles from North Gondwana Cambro-Ordovician sandstones, which provide a novel perspective on the cooling and unroofing history of their Pan-African provenance areas. Detrital rutiles in the Cambrian of Israel and Jordan define a unimodal age concentration at 0.59-0.58 Ga interpreted as representing widespread cooling and exhumation associated with late to post-tectonic igneous activity in the northern sectors of the Pan-African orogeny. This unimodal age spectrum does not change significantly up the Cambrian sequence, implying that late Precambrian exhumation cooled an ample amount of crustal material to below the rutile U-Pb closure temperatures (400 – 600°C) over vast areas. Therefore, rather than reflecting progressive erosion of massive Cambrian-age orogenic belts (Supermountains), the North Gondwana Cambrian sandstone represents secondary denudation of an already-exhumed, more subdued, Pan-African basement. Alongside the older (0.59-0.58 Ga) detrital rutile population, which dominates the Cambrian sandstone sequence, 0.55 Ga detrital rutile first appear in the Ordovician of Jordan, while 0.54 Ga rutile locally dominates the Ordovician of Ethiopia, some 2000 km upstream the Cambro-Ordovician fluvial system, closer to its headwaters. It thus seems that the Ordovician drainage basin has been extended southwards to include crustal terranes that were exhumed coeval with the final consolidation of Gondwana during the Cambrian. However, it is likely that most of the rock carapace that has been eroded from these consolidating Cambrian orogenic sutures has been delivered to the eastern and southern (modern coordinates) margins of the supercontinent.

MESOZOIC GLENDONITES: TRACERS OF METHANE SEEPAGE IN POLAR SEAS

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During the last 200 million years, Earth has experienced a number of extreme warming events associated with global carbon cycle perturbations. These events have often been attributed to the rapid dissociation of seafloor clathrates. However, several of these greenhouse episodes were shortly preceded or followed by brief icehouse episodes, e.g. prior to the T-OAE (Toarcian Oceanic Anoxic Event), after the OAE1a (Aptian), and during the Paleocene-Eocene. Cold, perhaps even glacial, conditions were inferred from the widespread high-latitude occurrence of glendonites, calcite pseudomorphs after the metastable mineral ikaite ($CaCO_3.6H_2O$), because ikaite is known to precipitate below 7°C. Here, we show that methane oxidation constitutes an overriding control on Mesozoic glendonite formation. Microscope observations on 33 Mesozoic glendonites from Siberia document a complex paragenetic sequence of carbonate phases, some of which being reminiscent of methane-derived authigenic carbonates known from hydrocarbon seeps.

Exceptionally heavy and light carbon stable isotope values (– 45 to + 20 ‰) recorded in glendonites and surrounding sediments, together with the occurrence of hydrocarbon gas inclusions, unequivocally evidence methane oxidation as a dominant process leading to glendonite formation. Our results thus demonstrate that glendonites provide an unexplored and unique archive for detecting past episodes of methane release and oxidation in polar seas.

SUBMARINE PALEOSEISMOLOGICAL POTENTIAL OF THE NORTHERN SUBDUCTION ZONE OF THE LESSER ANTILLES ARC

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On the Caribbean plate, the Lesser Antilles form a volcanic arc resulting from the slow subduction (2cm/yr) of the North American plate beneath the Caribbean plate. The general shape of the plate boundary is a bend resulting in a northward variation of subduction parameters, such as the degree of obliquity, coupling, thickness of subducting sediment and/or margin structure related to partitioning. The absence of major subduction earthquakes in recent historic records (Martinique, 1839, Mw ~7.5; Guadeloupe, 1843, Mw ~8, none in the northern segment) could suggest that the zone is relatively calm. The same hypothesis proved false for Japan and Indonesia as the major earthquakes of Tohoku Oki (2011, Mw=9.2) and Sumatra (Mw=9.5) occurred. To constrain the seismic hazard in the Lesser Antilles, the CASEIS cruise (DOI: 10.17600/16001800) collected 42 sediment cores and geophysical data (backscatter, bathymetry, CHIRP) along the forearc and accretionary prism in order to carry out a paleoseismological investigation based on earthquake-triggered turbidites. Data from Sismantilles (2007, DOI 10.17600/7010020), Gwadaseis (2009, DOI 10.17600/9020020) and Antithesis (2013, DOI 10.17600/13010070) cruises were also used to bring further details. In this study, we focus on the northern margin segment characterised by a strong convergence obliquity (up to ~60°) and a low sediment input also due to the presence of the Tiburon ridge located on the downgoing plate. To build a paleoseismological record, the coring strategy aims to 1) avoid turbidites originated from the shelf and thus limit any surge-or storm/wave-triggers, and 2) establish a correlation across distant sites fed by independent sedimentary sources to infer a regional trigger such as an earthquake. Seven sediment cores were collected in the segment NE of Anguilla. Four cores (CAS16-36PC, CAS1640PC CAS16-41PC, and CAS16-42PC) are located in 6 to 12 km-wide confined basins at the back of the accretionary prism, 35 to 100 km away from the shelf, in order to record only great turbidity currents. Two cores (CAS16-35PC and CAS16-38PC) are in 3-km wide confined basins at the foot of the slope. Core CAS16-39PC is in a slope basin not connected to shelf sedimentary input and represents local tectonic activity. Overall, all cores contain both coarse-and finegrained turbidites with intervening hemipelagites. Transparent layers in sub-bottom profiles are interpreted as homogenites with a sandy and laminated basal layers overlaid by homogeneous mud. Collected at 4681 m, CAS1639PC is an ideal core for a paleoseismological study. Both siliciclastic and carbonated turbidites are visible, attesting of at least two different sediment sources. Turbidites in this core may have two origins: subduction earthquake but also local minor earthquake related to the activity of nearby faults. Backscatter highlights different flow paths along well marked gullies which show that the basin is filled by its southwestern and northeastern edges. A preliminary correlation is established based on colorimetric parameters (L, a, b), magnetic susceptibility and gamma density. The results are promising, supporting the feasibility of a turbidite paleoseismology approach. It now needs to be verified by ongoing radiocarbon dating.

A 3D GEOLOGICAL MODEL DEVELOPMENT FOR SEISMIC WAVE PROPAGATION MODELLING, IN A CONTEXT OF DESTRUCTION OF SECOND WORLD WAR BOMBS (ANR POSA)

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The project POSA focuses on the seismic risk generated by bombs and mines blasting. It is based, first, on acoustic and seismometers measurements during blasting actions and secondly, on numerical modelling of anthropic-induced seismic wave propagation. To achieve these objectives, it is necessary to assess to the most faithful 3D representation of the seabed sediments and underlying rocks, using new acquired data but also all data available in databases and literatures.

The construction of the 3D environmental model is set into two phases. The first one consists in treatment and interpretation of all available historical and new data. A DEM of the topography and bathymetry is realized using data from POSA project field measurement, and Shom and IGN data coming from Litto3D, HOMONIM, PREVAG and BD-Alti projects. A seabed map is done after the interpretation of sedimentary data from Shom's database (cores, grabs, lead lines, multibeam backscatter imagery and seabed classification system). Sediments thickness is interpreted from seismic data acquired during POSA surveys with sub-bottom profilers. Thickness of sediment layers are adjusted by a factor depending of sound celerity of each sediment type and allow to derive the underlying rocks elevation. Marine and earth rocks, are derived from BRGM terrestrial geological map and, in submarine area, from few rock samplings and from old scientific studies. Physical properties of bedrock and sediments (celerity and attenuation of P and S waves, grain size, porosity, density) are obtained by laboratory and in-situ measures or from literature. They are essential parameters in seismic and acoustic wave propagation models. All data are processed on in a GIS software. The second phase consists in the gridding of the layers and the integration in a 3D modelling software.

A realistic 3D environmental representation of a submarine and a terrestrial zone has been done using all data and information available. This 3D geological and sedimentary model will improve the numerical modelling of seismic wave propagation. This model also highlights the gap between initial data and the necessity to improve the knowledge of geophysical properties of sediments and rocks, especially in submarine area. Other environmental applications should derive from this 3D model as morpho-sedimentary study of coastal zone (marine dune and beach dynamics, coastal management, volume variations of sediments layers and sand and gravel mining). The coupling of this geological model with the hydraulic part is the expected further sequence of this model in order to have access to the input data of acoustic models but also models of sediment dynamics.

A NOVEL 4D-VIEW ON SEDIMENTS: INSIGHTS TO SEDIMENTATION PROCESSES AND POST-SEDIMENTARY MINERAL FORMATION

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Lake sediment archives are well studied around the globe and contribute greatly to our understanding of past environments and climates. Yet, traditional sedimentological analyses are either limited to a 2D study of the sediment core surface, or volumetric analysis, for which the sedimentological structure needs to be destroyed. To overcome these limitations, we combined high-resolution 3D-microCT-scanning (µmscale) of fresh lake sediment with XRF-scanning, micro-XRF mapping, and traditional thin section analysis. MicroCT-scanning facilitates the observation of sedimentary structures at the mm-scale in 3D priorto analysis, while high-resolution mapping in 2D aids characterisation of the observed structures once the fragile sample is conserved in resin.

We present a study of sediments from Lake Towuti (2.75°S, 121.5°E), one of the oldest and deepest lakes in Indonesia. Cores of the entire sediment infill have been recovered in the ICDP Towuti Drilling Project in 2015, including lacustrine sediments covering several glacial-interglacial cycles. Located in the ultramafic East Sulawesi Ophiolite, the lake is highly ferruginous but poor in sulphur and among the least productive tropical lakes on Earth (ultra-oligotrophic). In the cores, high density contrasts between the clay-rich sediment matrix and postdepositional alteration products such as siderite ($FeCO_3$) provide an ideal setting for microCT analysis on characteristic sediment core sections. Geochemical information from the embedded sections is provided by high-resolution XRF-scanning (200 µm spacing) and micro-XRF mapping (50 µm spacing) of the samples.

MicroCT scans reveal µm-thick vertical voids filled with high density mineral precipitates related to post-depositional fluid circulation, as well as coatings of high-density material (mainly siderite), around low-density centres. We also observe beds of high-density minerals, which appear continuous in 2D, but prove to be separated structures in 3D space. A crack showing vertical displacement in the sediment is, in 3-D space, visualised as a plane of higher density material, which points towards a rupture, perhaps seismically induced, that promoted precipitation of high-density minerals on the newly-formed surface. The combination of high-resolution imaging with XRF element scans allows a novel, very detailed 4D-view of sedimentary structures that identifies processes involved in authigenic mineral formation and their relation to paleoenvironmental changes in the lake and its catchment.

DIAGENESIS OF THE MESOZOIC CARBONATES OF THE NORTHWESTERN PYRENEES: ORIGIN OF DOLOMITIZATION AND BRECCIATION

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We present the first results of a new sedimentological and diagenetic study of the Mesozoic carbonates in the Chaînons (ranges) béarnais, the Arbaille syncline, and the Arberoue and Lichançumendy structures (Béarn and Basque countries, north-western Pyrenees, France). The study aims to constrain the origin of heavy fracturing, brecciation and dolomitization that are observed locally.

The carbonates, which are Bajocian to Barremian in age, consist in a succession of platform and ramp deposits generally of E-W polarity. In the Mail Arrouy and Sarrance chaînons, Middle Jurassic carbonates form dolomitized barriers, which pass laterally to external platform and basinal facies in the Basque Country. The Upper Jurassic is marked by a change to ramp facies. In the Béarn, the facies are more internal, with argillaceous mudstone (Kimmeridgian) and intertidal dolomite (Tithonian). In the Basque Country and the Layens chaînon, these carbonates are partially eroded or absent. Finally, the sedimentation restarts during the Barremian, with high-energy carbonates to the north (Mail Arrouy, Sarrance chaînons and north flank of the Arbaille syncline). To the south (Layens chaînon, southern flank of the Arbaille syncline), the first Cretaceous deposits are lower Aptian. This sedimentary gap suggests a major regional uplift.

The diagenetic study has mostly focused on the Callovo-Oxfordian carbonates of the Chaînons béarnais (Meillon Formation), which consist in dolomitized oolithic barriers to the north (Mail Arrouy and Sarrance), and low energy mudstones to the south (Layens). Petrographical observations (optical and cathodoluminescence) suggest an early dolomitization phase common to the three chaînons and resulting in complete dolomitization of the oolithic facies, and the presence of isolated dolomite rhombs in the mudstones. Subsequent burial diagenesis differs according to the chaînon considered. In the Mail Arrouy and Sarrance chaînons, the Meillon Formation presents two dolomitization phases associated with several fracturing episodes. In the Layens chaînon, it consists in dedolomitization of the early dolomite cement, followed by precipitation of five calcite cement generations. These distinct diagenetic pathways suggest again the uplift of the southern part of study area (Layens) possibly during the Neocomian, allowing the inflow of meteoric fluids, contrasting with the inflow of Mg-rich fluids to the north, in association with more intense fracturing and brecciation (Mail Arrouy and Sarrance).

In addition to the structural analysis of fracture generations, petrographical, geochemical (C, O, Sr isotopes, D47 on dolomite, U-Pb dating of calcite cements) and fluid inclusion analyses are in progress or planned, to decipher the conditions and timing of intense dolomitization and brecciation. In particular, we aim to constrain if these peculiar diagenetic transformations are related to the Cretaceous hyper-extensive phase, which was associated with mantle exhumation and hydrothermalism, or to subsequent Pyrenean shortening.

These results will be compared with those obtained in the Basque Country more to the west (Arbaille, Arberoue and Lichançumendy structures), where Pyrenean shortening has been less intense, allowing the preservation of rift-related extensional structures.

TRACE AND RARE EARTH ELEMENTS IN BIVALVE SHELLS: SOURCING ARCHAEOLOGICAL SHELLS FROM UNKNOWN LOCATIONS

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Oyster shells have been found in the antique site of Lyon/Cybèle, which is located in east-central France, 300 km from the closest Mediterranean coast and 500 km from the Atlantic coast. As oysters can survive several weeks out of seawater, they were consumed by the Romans quite far from their living localities. Although a Mediterranean provenance of the oysters is probable, other bivalve specimens endemic to the Atlantic coastline have been unearthed from the ruins of the region, raising doubt as to their locality of origin. Morphological features from the shell remains have been used to define two groups amongst the oysters found in Lyon/Cybèle: a first group is thought to have been transported from the Mediterranean Sea, while the second group is said to originate from the French Atlantic coastline. A definite answer regarding the origin(s) of these shells would be beneficial for two reasons: first, it would provide insight into trade routes during the Antiquity in France; second, shells with a clear identification of their living localities could be used for past environmental reconstructions from specific localities by geochemical proxies such as stable isotope and elemental ratios.

The chemical composition of bivalve shells reflects that of seawater at the time of biomineralisation. It is therefore possible to recover locality-specific geochemical signatures from a particular shell. Especially, Rare Earth Elements (REE) data deliver information on the composition of weathering products transported to the shore by regional rivers. This study is based on trace elements and REE measured by LA-ICP-MS on archaeological shells from Lyon/Cybèle. Results were compared to equivalent analyses on modern specimens bred on the French Atlantic coast, which was selected as a reference location due to its relatively homogenous land surface lithology, contrary to the Mediterranean shore.

Results indicate that REE profiles of modern specimens reflect that of regional deposits, confirming the use of REE in bivalve shells for sourcing archaeological malacofauna remains. REE profiles from the two archaeological shell groups exhibit similar patterns, with one group presenting statistically lower concentrations than the other. These patterns are different from the modern Atlantic signature. Strontium and barium concentrations also allow modern Atlantic shells and archaeological shells on to be discriminated, with different Sr concentrations between the two archaeological groups. We propose that the oysters from Lyon/Cybèle are not from a locality from the French Atlantic coast. The two archaeological groups defined from morphological features are also discriminated by their composition, but were probably living in adjacent areas subject to the same continental REE input, with one group collected from a closer location to the source than the other.

EXPERIMENTAL EVIDENCES OF MODULATION OF EROSION RATES OF UPLIFTING LANDSCAPES BY LONG-TERM CLIMATE CHANGE

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Whether climatic variations play a major role, or not, in setting the erosion rate of continental landscapes is key for demonstrating the influence of climate on the tectonic evolution of mountain belts, as expected from analytical, numerical and analog modelling approaches. These models actually demonstrate that any modification in surface erosion rate that would affect significantly the gravitational loading of the continental crust might change its state of stress and consequently its deformation. However field evidences of these interactions has proved challenging to demonstrate unambiguously, the question of the climatic control on erosion efficiency at the geological time-scale being among the most critical issues.

Here, we investigate how a change in precipitation influences the erosional dynamics of a landscape on the basis of an experimental approach where we surveyed the erosion by runoff of water of laboratory-scale landscapes that evolved under the combination of uplift and rainfall forcings (e.g. Bonnet and Crave, 2006). The experimental facility used is a modified of a device initially developed in the Geosciences Rennes laboratory and now set up in the Geosciences Environnement Toulouse laboratory. Following early experiments of Bonnet and Crave (2003) where the effect of a sudden drop in precipitation was investigated, we consider here the impact of decreasing rainfall events of finite duration on the erosive response of a landscape forced by a constant uplift (10 mm/h) and initially at steady-state (SS1). We performed several experiments with the same amplitude (from 160 to 60 mm/h) but with different duration of rainfall drop (Tp: 0, 60, 300, 500, 700 min). As predicted theoretically and already observed in numerical and experimental modelling studies, a sudden drop of precipitation rate (Tp=0) induced a decrease of the mean erosion rate of the landscape (E), resulting in surface uplift. Then, landscape mean elevation stabilized to a higher value as it recovered a new steady-state (SS2). On experiments with a gradual (linear) decrease of precipitation of finite duration (Tp > 0), we observe that the onset of surface uplift and of decrease in erosion rate is delayed with regard to the onset of precipitation change and occurs only after a period where landscapes remain very close steady-state.

The duration of this delay differs between experiments and increases linearly with Tp. Beyond this delay, the mean erosion rate then drops to a minimum value, while knickpoints migrate in the drainage system following the mechanism described by Whipple and Tucker (1999). We observe that the amplitude of the drop in mean erosion rate decreases with Tp, experiments with the longest duration of precipitation drop showing a damped erosional response, representing only about 20 % the uplift rate value ((Tp=700 min). As a perspective we anticipate that experiments with longer Tp would ultimately not show any significant erosional response to precipitation variations.

FACIES AND STABLE ISOTOPES ANALYSIS FROM CENOZOIC GRAVELS DEPOSITS, AND PALEOENVIRONMENT-CLIMATE INTERPRETATION, CENTINELA MINING DISTRICT, ATACAMA DESERT, CHILE

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The Atacama Desert is considered the driest place in the world, with a Cenozoic history of semi-arid to hyper-arid climate conditions. A series of Cenozoic basins records the paleoclimate desert evolution. The Centinela District contains several sequence of Cenozoic gravels that allow understand the evolution of this segment of the Atacama Desert.

Our facies analysis determines facies association, and together with stable isotopes analysis of Carbon-Oxygen, allow us to propose a paleoenvironment/climate evolution. Five informal units have been defined based on their sedimentology and stratigraphic relationship. What follow is facies association (e.g. A1) for each unit. The first unit is Esperanza Gravels that has a volcanic ash layer interbedded with 42 Ma. and unconformity overlay the Upper-Cretaceous basement. Esperanza Gravels is composed of facies association (A1) which consist of unconfined to poorly confined stream-flow deposits, with block and ash sequences. The second unit is Atravesado Gravels that has a maximum depositional age of 39.9 Ma. and unconformably overlay Esperanza Gravels. Atravesado Gravels is composed of (A2) and (A3) which represent unconfined debris-flows, and mudflows with subaerial waning flood flows respectively, and of (A4) which is streamflow dominated and has calcretes interbedded. In relation with the entire unit, these calcretes facies become less negative in $\delta^{13}C$, showing more humidity conditions. Tesoro I Gravels is laterally chronostratigraphic related with Atravesado Gravel, and is composed of (A2). Tesoro II and Tesoro III Gravels unconformably overlay to the previous units and have maximum depositional age of 40.4 Ma. They are composed of (A5) and (A6) respectively. (A5) consist in streamflows with shallow lacustrine limestone, and (A6) consist in sheetflow and debris-flow with streamflow interbedded. Arrieros Gravels is disposed in slightly angular unconformity over Tesoro III Gravels. It is composed of (A7) which consist on sheetflow and minor streamflow with debris-flow and evaporites interbedded. It is characterized by the development of gypsisol above the deposits which is covered by an ash layer of 9.52 Ma. A wide-spread pediment surface has been developed over Arrieros Gravels deposits. The $\delta^{13}C$ and $\delta^{18}O$ shows a slight positive correlation towards the top, following the evaporation curve. Finally, Arrieros Silts and Marls unit is isolated, embedded on Arrieros Gravel unit filling a paleovalley. It is composed of (A8) which consists of fine grain debris-flow, subaerial waning flood flows, palustrine marls and restricted evaporites and coal.

Esperanza Gravels represents a wide spread alluvial braid-plain. Atravesado Gravels and Tesoro I Gravels depicts a middle to distal alluvial fan environment that changes to a braided fluvial system. Tesoro II and III Gravels represents a high energy braid plain with shallow lakes and proximal alluvial fans. Arrieros Gravels depicts a distal alluvial braid plain. After its deposition an extreme climate desiccations occurred that allow development and conservation of the gypsisol, and also the pediment surface develop. It can be correlated with the wide spread Atacama Gravels deposits. This unit mark in the basin the onset of hyperaridity. Finally, Arrieros Silts and Marls represent a wetland environment, created by a wet pulse within hyper-aridity trend.

HISTORY OF EARLY DIAGENETIC TO LATE TECTONIC TRANSFORM FAULT OVERPRINT ON TEXTURAL PATTERNS AND ISOTOPIC SIGNATURES OF MESOZOIC DOLOSTONES

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The objective of this study is to disentangle a long and complex succession of early to late diagenetic and subsequent tectonic overprint affecting the textural and geochemical composition of Mesozoic carbonates along the Carboneras Fault Zone (CFZ) in SE Spain. By this we intend to exemplify the strength of detailed fieldwork combined with geochemical analysis of sedimentary rocks in the laboratory and petrographic description of thin-sections in deciphering diagenetic and anchimetamorphic pathways. A suite of rock samples collected along the Neogene Carboneras transform fault represents increasing stages of diagenetic and tectonic overprint. Following deposition and initial lithification, the diagenetic history of these peculiar samples commences with early dolomitization of shoalwater carbonates. Evidence for early stage dolomitization comes from well-preserved sedimentary features such as ripples and fining-upward features. During burial, the dolostones experienced a series of complex dissolution-reprecipitation steps leading to the formation of “zebra” fabrics, i.e. bedding-parallel, elongated voids filled with what are now saddle dolomites. Blocky saddle dolomite and the presence of stylolites indicate that zebra formation was caused by induced stress and precipitation from hydrothermal fluids. Transmitted light-and cathodoluminescence microscopy display several paragenetic phases of dolomite, representing the patch luminescence (and hence overprinted) early diagenetic dolmicrite matrix, blocky saddle dolomites formed upon burial, and late diagenetic cements most likely related to Neogene transform fault activity. Besides dolostones, calcite marbles with minor amounts of dolomite and sedimentary features similar to those in the dolostone are found in places. Analysis of $\delta^{26}Mg$, $\delta^{13}C$, $\delta^{18}O$, and $^{87}Sr/^{86}Sr$ in early and late dolomite phases allows to distinguish between properties inherited by the limestone precursor and those formed during dolomitization, as well as to distinguish between pre-and syn-fault diagenetic processes and conditions. Variations in $\delta^{26}Mg$ help to understand how alteration by the fault changed the isotopic composition of the early diagenetic dolomite and provides information on the source of deep seated, non-marine fluids during overprint by the CFZ. The $^{87}Sr/^{86}Sr$ isotopic ratio of carbonates serves as a geochemical fingerprint for diagenetic fluids and the fluid source.

GIANT CANYONS AND CHUTE POOLS IN DEEP-SEA CARBONATE ENVIRONMENT (BAHAMAS)

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New high-resolution multibeam mapping, in the Bahamas, images in great details the southern part of Exuma Sound and the deep part of the Little Bahama Bank. In both area, the most singular feature concerns the transition area to the deep abyssal plain (water depth: 5000 m) of the Western North Atlantic bounded by the Bahama Escarpment (BE). In both areas, the newly established map reveals the detailed and complex morphology of giant valleys formed by numerous gravity flows, the Great and Little Abaco canyons along the Little Bahama Bank (LBB) slope, and the Exuma Canyon in the Exuma area. In the Great Abaco Canyon, the sediment is fine grained and originates essentially from valleys side (LBB) including slided material and supply from many secondary slope gullies and smaller tributaries draining the surrounding upper slopes. In the Exuma Canyon, a part of the material comes from the adjacent slope but adds to a fraction of sediment coming from the upper slope. In both cases, the initial valley abruptly transforms itself into a deep incised canyon, rivaling the depth of the Colorado Grand Canyon, through two major knickpoints with outsized chutes exceeding several hundred of meters in height, a total of almost 2,000 m. The sudden transformation of the wide valley into a deep narrow canyon, occurring when the flows incised deep into an underlying lower Cretaceous drowned carbonate platform, generates a large hydraulic jump and creates an enormous plunge pool and related deposits with mechanisms comparable to the ones operating along giant subaerial waterfalls. In the Exuma Sound example, the high kinetic flow energy, constrained by this narrow and deeply incised canyon, formed, when it is released at its mouth in the abyssal plain, a wide deep-sea channel with well-developed levees and fan, made of coarse-grained carbonate defined layers separated by fine carbonate sediments mixed with fine siliciclastics transported along the BE by the energetic Western Boundary Undercurrent. Conversely, in the Little Bahama Bank example, the canyon mouth only reveals a small lobate structure with a thickness that does not balance the volume of sediment missing in the canyon, probably because of the pirating of fine-grained sediment by deep-sea contour currents.

HIGH-RESOLUTION CARBONATE SLOPE MORPHOLOGY REVEALING SEDIMENT TRANSFER FROM BANK-TO-SLOPE (LITTLE BAHAMA BANK, BAHAMAS)

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New very high-resolution multibeam and seismic data (CARAMBAR 1.5 cruise – 2014) allow imaging of a large part of the uppermost slope of Northeastern Little Bahama Bank between 20 and 300 m water depth. They add to data collected during Carambar cruise (2010). The data provide insight into sediment transfer from the shallow carbonate bank (< 10 m) to the adjacent slope. Several submerged coral terraces and escarpments dominate the morphology of the upper part of the uppermost slope. The terraces could be related to Late Quaternary eustatic variations and are interpreted either as sea-level stillstands or as waveravinement surfaces. Increased erosion by waves during either periods of stagnating sea-level, or periods of accelerated sea-level rise since the Last Glacial Maximum could be a possible cause for these terraces.

The lower part of the uppermost slope shows a discontinuous Holocene sediment wedge with varying thickness between 0 and 35 m. It is separated from the upper part by a highly cemented sea-floor area forming the marginal escarpment at the base of the lowermost terrace. Passing cold fronts result in sediment export caused by density cascading. The probable associated sediment fall-out and convective sedimentation can generate deposition of periplatform ooze that forms this Holocene wedge. Wedge destabilization can be the cause of the linear structures extending downward on the upper slope. In addition, the survey reveals the presence of recently active channels that extend over the entire uppermost slope and interrupt the wedge. These channels are settled on the side of sub marine cone shaped topographic highs representing probably the remnants of lowstand deltas that were active during the Last Glacial Maximum. The channels connect upslope to disrupted parts of the barrier, which form passes between small islands and shoals. In these passes, acceleration of tidal currents at velocity > 1 m/s allows downslope export of fine-grained carbonates whilst coarse-grained particles such as ooids and bioclasts remain trapped in tidal deltas. The successive connection of channels to shallow tidal passes to submarine valleys to the proximal part of canyons directly feeds these canyons with platform-derived sediment forming very low-density turbidity currents transporting fine-grained particles. The currents deposit a fine-grained carbonate mud blanket within the canyon, which extends from canyon head down to thin lobes up to 40 km downslope. At present-day, most of sediment export would thus be due to tidal currents with increased activity during ebb tides, occurring after hurricanes or passing cold fronts generating density cascading.

Little Bahama Bank shows at least two major periods of activity: canyon formation by retrogressive erosion and partial filling during highstand periods when carbonate platform is flooded and the carbonate factory is active. During largest highstand, carbonate production is intensified and export can lead to the construction of small channel levee complexes.

SEDIMENTOLOGICAL AND EPIGENETIC FACTORS OF STRUCTURAL HETEROGENEITY OF SANDS AND SANDSTONES OF BITUMEN DEPOSITS IN THE VOLGA-URAL REGION OF RUSSIA

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Thermal methods associated with the injection of hot water vapor into productive horizons are effectively used in the exploitation of viscous oils and natural bitumen deposit in Permian bituminous sands and sandstones of the Volga-Ural region (Russia). A problem is the unpredictable circulation of high-temperature fluids caused by uneven heating of rocks due to the heterogeneity of reservoir properties. The main purpose of the work was to find out the causes of this heterogeneity in connection with the exploitation by thermal methods. For this purpose, a complex mineralogical petrographic and geochemical study of bituminous rocks was carried out. Bituminous rocks in the region under consideration occur as intervals in often crossbedded, mainly small-and medium-grained, polymictic sands and sandstones. In the mineral composition quartz and feldspar prevail. In addition, fragments of magmatic rocks and minerals (amphiboles, biotite, effusive rock particles) are present. The nature of the pore space of the sandstones is one of the most important parameters of their capacitive-filtration properties (CFP). For the formation of intergranular pores and increased collector properties of rocks, a favorable factor is the weak roundness and angularity of the fragments of minerals. It is established that the pore space in the rocks of oil-saturated sediments is represented by a system of communicating and isolated pores. An important factor in reducing the CFP of sandstones is the formation of cementation zones, which occur primarily below the water-oil contact zone. Regarding this, we identified three groups (tar sands, weakly cemented sandstones and cemented sandstones), which differ in their reservoir properties. Obviously, vertical zoning, due to the location of the oil saturated zone, the water-oil contact zone and the cementation zone, should appear in the ideal deposit. However, the actual structure of the observed bituminous deposits is characterized by the presence of rocks cemented with carbonate minerals at various levels and configurations, which is also accompanied by a complex distribution of the isotopes of Th, Ra, and K. It can be assumed that the oil reservoir was in a dynamic state during its formation, which may be due to local geodynamic movements. The process was also complicated by the degradation of the oil substance, which is in constant contact with oxygen-containing waters in near-surface conditions. Thus, the reason for the heterogeneity is related to the conditions of sedimentation of sands and sandstones, as well as by complex conditions of transformation of the initial rocks during formation of the deposit and formation of zones of cementation under the action of oil waters.

GEOCHEMISTRY OF THE FINEGRAINED SILICICLASTICS OF SIWALIK GROUP OF ROCKS FROM ARUNACHAL HIMALAYA: IMPLICATION FOR SOURCE AREA WEATHERING, PROVENANCE AND TECTONIC SETTING

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Fine-grained siliciclastic deposits of the upper part of Neogene Siwalik succession in and around Itanagar, Arunachal Pradesh, have been geochemically examined for major, trace and rare earth element compositions, in order to have an insight on the lithological composition, source area weathering, provenance and tectonic setting of the provenance. Petrographic studies have indicated that the Siwalik sedimentary suites have formed in a recycled orogenic setting with varied modal composition of Q(56-82%)F(15-37%)L(10-26%). The plot of Th/Sc vs. Zr/Sc is in agreement with the process of sediment recycling, with implication of the addition of zircon from a weathered source. A moderate to high weathering condition at the source area is indicated by the average CIA value of 72. Positive correlation of major oxides in the bivariate plots of Fe_2O_3, K_2O, Na2O, TiO_2, MgO, and P2O5 relative to Al_2O_3, also indicate clay mineral control on the major oxide composition of this deposit. Enriched LREE and broadly flat HREE pattern, along with the (Gd/Yb)N ratios ranging from 1.5 to 1.77 are attributed to a felsic source; sharp negative Eu anomaly (0.54 –0.76, mean 0.65, similar to UCC ~ 0.63) emphasizes in a differentiated silicic sources, alike that of Granite. Elemental ratios of La/Lu, La/Sc, Th/Sc, La/CO, Th/CO and Cr/Th bolster our conclusion of felsic provenance of the Siwalikrocks. Again, ratios of LaN/YbN, LaN/SmN, CeN/YbN and LA-Sc-Th plot collectively suggest the source to be LREE enriched and HREE depleted and which in turn suggests the rock to be derived dominantly from felsic igneous rocks and/or reworked metasedimentary/sedimentary sources. Again, from the near similar pattern of trace and REE distribution and Eu/Eu* vs. (Gd/Yb)N plot, we can infer the deposits to be geochemically correlateble with a UCC type source terrain. Similar geochemical traits of the studied samples with respect to that of the Proterozoic granitoid data reported from the Arunachal Lesser Himalaya at close proximity of the study area, led us to assign Lesser Himalayan rocks to be one of the major contributors for the Siwalik sedimentary deposits here. Paleocurrents measured from field data validates the same by stating a south to southwestern flow directions from a northernly occurring provenance. A passive margin setting for the source terrain is also consistent with the earlier conclusion.

DIAGENETIC SIGNATURES WITHIN ACIDIC LACUSTRINE DEPOSITS ON EARTH – APPLICATION TO MARS

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The Curiosity rover from the NASA MSL (Mars Science Laboratory) mission is currently exploring the Martian geological deposits within Gale Crater. In September 2014, Curiosity reached the lowermost exposed portion of the Murray Formation: laminated mudstones, that have been interpreted as representing an ancient lacustrine environment. Yet, the characteristics of this ancient lake remain quite unknown. For example, the water/sediment ratio, as well as the duration of watersediment interaction are unconstrained. Two main hypotheses have currently been proposed to explain the variability in mineralogy and chemical composition of those lacustrine mudstones: (a) sediment deposition in lake waters that had variable pH, and (b) early diagenesis of sediment by acidic pore fluids or groundwaters.

Our study is focused on the early diagenesis of fine-grained (silt-clay) iron-rich sediments deposited in Spring Creek Reservoir (SCR), California, where the pH has risen from about 2 to about 6 (with seasonalvariation) in response to lime-neutralization treatment of mine effluents and site runoff. Acidic water draining into SCR comes from oxidation of massive sulfide mineral deposits at Iron Mountain, located approximately 8 km upstream. We are determining the nature of the matrix and cements that form within the fine-grained reservoir sediments. Sampling at SCR was done in July and September 2016 along a transect from the reservoir shoreline to sites up to 150 cm higher in elevation, where sediment was deposited in past years when the reservoir was nearly full of water. Within each core, subsamples from depths up to 30 cm are being studied to assess the matrix/cement, as well as the influence of different rock-water interaction ratios. Samples of streambed sediment, efflorescent salts and bacterial mats were also collected upstream from SCR.

SEM imaging analyses show that a diversity of mineral phases is present among the sediments. Preliminary visual identifications indicate iron oxides, jarosite, as well as several clay minerals, including halloysite and kaolinite. The presence of those phases is confirmed by preliminary XRD analyses. Mineral ratios from XRD indicate that the quartz content is relatively homogeneous among the different samples, whereas the plagioclase content is lower in samples in contact with the reservoir waters; this suggests the plagioclase is being altered within the reservoir. Within the reservoir sediments, halloysite, smectite, and illite contents correlate and are higher compared to upstream streambed sediment, consistent with formation of those phases in situ. XRD analyses also indicate the presence of rectorite; this phase was present at higher concentration within a cyanobacteria mat sample. We are currently working on characterizing all the main authigenic phases present within those sediments to understand their origin, and thus determine their possible application for constraining the observations made by the Curiosity rover at Gale Crater.

SEQUENCE ARCHITECTURE AND DEPOSITIONAL EVOLUTION OF PALEOGENE SYNRIFT TO EARLY POST-RIFT STRATA IN THE BAIYUN SAG OF THE PEARL RIVER MOUTH BASIN, SOUTH CHINA SEA

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The South China Sea is located at the intersection of three plates and exhibits a complex evolution from synrift to post-rift to, locally, compressional stages. This study focuses on the Baiyun Sag and adjacent Panyu Uplift of the Pearl River Mouth Basin with the goal of constructing the sequence architecture and depositional evolution of the Eocene – Early Oligocene synrift to the Late Oligocene early post-rift stages of basin evolution. The Baiyun Sag represents a half-graben and the Panyu Uplift to the north defines a hangingwall ramp. This study utilizes 3-D seismic data complemented by well logs and cores and reveals that the package of strata is comprised of three composite (second-order) sequences made up of five thirdorder sequences for the lowermost, synrift Wenchang Formation, three third-order sequences for the synrift Enping Formation, and six third-order sequences for the early post-rift Zhuhai Formation. Composite sequence boundaries are defined by truncation unconformities and can be identified across the whole study area. In contrast, third-order sequence boundaries are recognized on the basis of toplap and offlap characteristics and are best developed in center of the Baiyun Sag. Twelve seismic facies are identified on the basis of different internal reflection configurations, external shapes and contact relationships. Lithofacies are recognized from gamma ray well-log shapes complemented with cores. Based on the distribution of seismic facies and lithofacies, the Wenchang and Enping formations consist of alluvial fan and fan-delta deposits adjacent to the southern fault scarp and braid delta deposits on the adjacent ramp. Central rift basin deposits of the Wenchang and Enping formations are dominated by lacustrine mudstones and sublacustrine fan deposits. The overlying Zhuhai Formation is dominated by shelf and shelf slope environments and developed as southward-prograding deltas and submarine fans. Tectonics was the principal controlling factor on the development and distribution of sequences and depositional environments during the synrift stage. In contrast, sea-level changes superimposed on long-term, thermotectonic subsidence determined the stacking patterns of sequences and depositional environments during the post-rift stage. This study is the first documentation of the synrift to early post-rift depositional history of the Pearl River Mouth Basin.

FLUID EVOLUTION DURING GROWTH OF THE SANT CORNELI-BÓIXOLS-NARGÓ ANTICLINE (COLL DE NARGÓ AREA, SOUTHERN PYRENEES)

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The South-Pyrenean fold-and-thrust belt is an ideal natural case for the study of fluid-migration during orogenic compression. The study area comprises the southern limb of the eastern sector of the Sant Corneli-Bóixols-Nargó anticline and its related footwall Coll de Nargó syncline. Structurally speaking, the Sant Corneli-Bóixols-Nargó anticline is the leading edge of the Bóixols thrust sheet, corresponding to the oldest thrust sheet of the South Pyrenean unit, emplaced from Upper Cretaceous to Paleocene. It was interpreted as a fault-propagation growth fold related to the inversion of a Lower Cretaceous extensional fault. Bóixols thrust itself is buried by synorogenic sediments deposited during anticlinal building, as consequence, blinded fault's propagation was accommodated through a complex deformation pattern in his fossilizing sediments. Joints and strike-slip faults resulted mineralized by calcite cements, testifying that such structures allowed the fluid-flow in the studied anticline. $\delta^{13}C$ values of calcite cements show correlation with stratigraphic units and highlight a strong control of lithology on the fluid isotopic signature. On the other hand, calcite cements $\delta^{18}O$ values results constantly depleted when compared to adjacent host rock. Thanks to the petrographic study combined with $\delta^{18}O$ and $\delta^{13}C$ analysis, 4 types of fluids have been identified, flowing in different times during the evolution of the anticline. During the beginning of folding processes a strongly ^{18}O-depleted fluid is recorded, and later a more ^{18}O-enriched fluid flew along the syn-folding joints. Afterwards, when the anticline reached her maximum amplification and could not easily accommodate any further orthogonal shortening, deformation found his expression trough the generation of a complex strike slip faults' conjugate set. Cements precipitated in strike slip faults are strongly depleted in $\delta^{18}O$. Precursor elements of strike-slip fault resulted filled by cements with two distinct isotopic signatures: first, by cements in isotopic equilibrium with the affiliate host rocks and then by cements having same isotopic signature of the ones encountered in faults. This data suggests a paleo hydrological closed system during pre-slip fracturing stage, and attribute to strike-slip faults the responsibility to bring-in a new ascendant hotter fluid. Strike-slip faults here confirm themselves as elements that could enhance fluid circulation, bringing vertical connection and forming wide and well developed damaged zone where fluid-flow can occur along faults and associated background fractures.

TWO INDEPENDENT DUNE GROWTH MECHANISMS AND THEIR DEPOSITS

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Using a combination of field observations, model simulations and laboratory experiments, we show that a single multidirectional wind regime can lead to two different dune orientations depending on sand availability. The erodibility of the bed selects the overriding mechanism for the formation of dunes. Hence, dunes may either (1) increase in height from the destabilization of a sand bed in zones with no limit in sand availability or (2) elongate away from a localized sand source in zones of low sand availability. In both cases, we present here the complete phase diagrams of dune shape and orientation for bidirectional wind regimes. Then, we analyze the sedimentary records of different dune types using numerical simuations.

TEX86-BASED SEAWATER PALEOTEMPERATURE ESTIMATES ACROSS THE ONSET OF THE MESSINIAN SALINITY CRISIS

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Glycerol dibiphytanyl glycerol tetraethers (GDGTs) are commonly used for deciphering paleoenvironmental conditions in sediments and the water-column as well as sea surface temperatures (SSTs). These compounds are particularly useful for the study of sedimentary successions deposited in ancient extreme environments, which usually lack of micro and macrofossils. We tested GDGT-based proxies (e.g. GDGT ratios, TEX86) on a section encompassing the onset of the Messinian salinity crisis (MSC) from northwestern Italy, with the aim of estimating variations in SSTs across the beginning of this event. This section does not contain evaporites, but rather carbonate layers that represent the deeper water counterpart of gypsum deposited in marginal areas (Dela Pierre et al., 2012). The TEX86 index was applied to calculate SSTs, which were obtained using both a calibration for high and low latitudes (TEX86L) and one that excludes the high latitudes (TEX86H) (calibration error ± 4.0 °C and ± 2.5 °C, respectively; Kim et al., 2010). The pre-MSC carbonates yielded average SSTs of ~23 °C for both calibrations. Such temperatures are consistent with SST cooling observed in the late Miocene on the basis of the UK'37 paleothermometer, based on alkenones. A GDGT pattern typical of marine Thaumarchaeota has been observed in these carbonates. Above the MSC onset, the overall GDGT inventory does not vary, but the relative proportions of GDGTs change. In particular, C20-20 archaeol and C20-25 extended archaeol, which are produced by halophilic archaea become much more abundant, pointing to a structural change in the archaeal community. At the same time a divergence of the SSTs calculated from the TEX86L and TEX86H is observed, ranging between 9 °C and 25 °C. Since no other paleotemperature data are available for this time interval, the observed SST divergence cannot be easily explained. A similar large ΔTEX86L-H offset has been reported from modern polar regions with SST< 15 °C, but such an environment is apparently unrealistic for the studied section, making the TEX86L calibration unsuitable for the analysed MSC samples. Alternatively, high ΔTEX86L-H values have been reported from shallow water settings of modern and ancient basins, where they are positively correlated with low GDGT 2/3 ratio. The simultaneous increase of the ΔTEX86L-H values and the decreasing GDGT 2/3 ratio (< 2) above the MSC onset, apparently suggests a shallowing of the basins. Therefore, the initial phase of the crisis in the Piedmont basin seems to be characterized by SSTs ~25 °C (as obtained from the TEX86H), which are surprisingly similar to both the pre-MSC SSTs and modern average Mediterranean SSTs. The information derived from archaeal membrane lipids can be used to increase our knowledge on a dramatically changing environment, but especially for sites where no constraints from body fossils are available.

ASSESSING THE INFLUENCE OF INTERMEDIATE STORAGE ON SANDSTONE COMPOSITION

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In a sedimentary system, the sediment composition can be modified from the source to the sink by various processes such as chemical and physical weathering, hydraulic sorting and/or mixing, which can occur during transport and intermediate storage. Certain minerals will be more easily weathered than others (e.g. feldspar, apatite), resulting in a change in the bulk sediment composition. This study intends to better comprehend the impact of these processes, with a specific focus on those occurring during intermediate storage. Ultimately, this study should help 1) predict sandstone reservoir quality and distribution; and 2) understand how provenance signals might be altered in the sedimentary environment. Storage, prior to final deposition, can occur on the shelf or on the alluvial plain, predominantly during highstand, when the base level favours sediment accommodation. In contrast, during lowstand, storage is unlikely to occur, and the previously stored sediment might be recycled and redeposited further down dip. Storage is thus dependant on sea-level fluctuations and different sedimentary facies might be linked with a specific type or duration of storage. The sediment modification occurring during storage is poorly understood. During such a phase, specific heavy minerals are likely to be more easily weathered than others (e.g. apatite vs. tourmaline). An examination of heavy mineral ratios may thus enable us to recognise if the sediment has been through a storage phase. Such fluctuations in the sedimentary record could also be due to a change of sedimentary sources, hence it is critical to constrain the provenance of the studied sequences. This project investigates a sea-level influenced siliciclastic record: namely the infill of the Clare Basin, western Ireland. During the mid-Carboniferous (Serpukhovian-Bashkirian) period, frequent glacio-eustatic sea-level fluctuations controlled deposition in this basin. This is an appropriate case study in which to investigate the above concepts because the sediments are likely to have experienced modification prior to ultimate deposition. Detailed sedimentary logging and sampling of the deltaic Tullig Cyclothem and of the deep water fan Ross Formation are being conducted. A quantitative petrographic analysis will be carried out in order to constrain the composition of the samples. Quantitative heavy mineral analysis will be accomplished using Secondary Electron Microscopy (SEM) as well as Electron-Dispersive X-Ray Analysis (EDX). The provenance of the same samples will be conducted using zircon and apatite U-Pb geochronology. These data will also help better understand the palaeogeography of the Clare Basin for which there are currently contrasting models.

A WEST-EAST TRANSECT THROUGH THE UPPER DEVONIAN SUCCESSION OF THE FRENCH PYRENEES: FACIES DISTRIBUTION AND PRELIMINARY BASIN DEVELOPMENT RECONSTRUCTION

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Red nodular cephalopod limestones, the famous Griotte Facies, are well-known from the upper Devonian strata in Southern France. In the Pyrenees they are restricted stratigraphically to the lower Famennian and spatial to mostly the eastern part of the mountain chain. Despite these restrictions, the Griotte Facies is often considered to be representative for the entire upper Devonian in the Pyrenees, and the development of very different detrital and carbonated facies are often hardly acknowledged. Nevertheless, the early Famennian corresponds to a time of general facies homogenization along the mountain chain with widespread installation of supposed deeper water, basinal nodular carbonate facies. A simple unique basin deepening to the northeast was hence proposed in previous studies. However, this simple model does not explain the important spatial and temporal variations in thickness and facies observed throughout the mountain chain especially in the Frasnian.

The westernmost succession in the Pays Basque is mostly composed of a thick Frasnian succession of sandstone and subordinated shales, followed by a thin package of nodular Famennian limestones. Although detailed modern sedimentological studies are lacking, these deposits are supposed to represent the most proximal settings in the basin. Further east in the western Axial High Chain a complex pattern of very different Frasnian facies are observed. A central siliciclastic facies realm (Sia Series s.l.), which contains turbidites in the lower part, is surrounded by a dominantly carbonated shallow marine facies belt containing stromatoporoid-coral biostromes. This spatial facies distribution suggests a relatively complex basin geometry, probably influenced by rapid eustatic variations with no clear source of detrital sediments within the central Pyrenees.

The most distal facies, and hence the deepest domain in the central Axial High Chain, are located in the upper Devonian strata of the Couserans. For the east part of the Pyrenees, the deepest domain is in the Aspres. Between these two domains, eastward, facies become progressively more proximal, dominated by nodular carbonated argillaceous facies with no coarse-grained detrital content, in contrast to the western Axial High Chain. The most proximal facies in this region is found in the synclinal of Villefranche de-Conflent, where the proximo-distal gradient is still expressed despite the facies homogenization during Griotte Facies time.

The very heterogeneous facies in the western part of the Central Pyrenees could be explained by movements of tilted blocks with active slope leading to variations between deeper and shallow facies, even on short distances. The tectonic movements could be interpreted as the premises of flexification of the foreland basin of the Variscan orogeny, which is definitively established in the Lower Carboniferous. The separation into larger blocks and their subsequent movements could also explain large-scale variations in thickness of some Frasnian carbonate series in the central and eastern part of the Pyrenees.

Hence, the onset of the development of the Variscan foreland basin in the Pyrenees results in the development of a complex upper Devonian basin, with the most complex structuration of several tilted blocks in the western and central part of Axial High Chain.

FLUVIAL VS EOLIAN ORIGIN OF PLEISTOCENE/HOLOCENE DUNES (SOUTH MORAVIA, CZECH REPUBLIC)

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The archaeological locality Pohansko (South Moravia, Czech Republic) represents evidence of a significant Early Medieval centre in the core area of the Great Moravian Empire, 9th century AD (interpreted as a munitio, emporium and palatium of the Moravian Early Medieval rulers). The site lies at an altitude of about 155 to 157 m a. s. l. and is situated within an extended flood plain near the confluence of the Morava and Dyje rivers filled with Holocene flood loams. The beginning of flood loam sedimentation is estimated to be about 3000-4000 BP at the initial phase of the Subboreal period. The marginal slopes of the valley protrude some 5 m above the flood plain and are composed of Middle Pleistocene (Riss) fluvial sandy gravels with Late Würmian dunes. In some places these dunes also protrude from under Holocene flood loams in the flood plain; one of them was used to build the Early Medieval fortified site. Originally the sand dunes had a height of between 6 and 8 m, but recently because of younger flood loam deposits, they are only 1-2 m above the flood plain. Some lower dunes were even buried under the flood loams. The bedrock of the Quaternary deposits in the area of Pohansko is represented by grey clays of the Pannonian Age (8.5-11.5 Ma) of the Vienna Basin. The yellowish to brownish fine to medium grained sands forming the dunes are traditionally interpreted as eolian in origin formed by wind-blown sands. Artificial newly outcropped profiles produced during the archaeological research were subjected to detailed lithofacies analyses. Morphoscopy of quartz grains were studied in selected samples. Age interpretations are based on optically stimulated luminescence (OSL)analyses. Based on these results, fluvial units predominate in the sedimentary succession and the dunes are interpreted as levees and point-bars. Aeolian origin of some part (?) of Pleistocene/Holocene dunes is therefore questioned. The dune could have originated in the Dryas III (Late Würm), i.e. 12 000-17000 BP and partly resedimented in the Holocene.

THE CONIACIAN-SANTONIAN UNCONFORMITY IN OFFSHORE WEST AFRICA: CHARACTERISTICS AND IMPACT ON RESERVOIR QUALITY

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A regional study integrating 3D basin modeling, geochemistry, seismic, sedimentology, petrophysics and petrography in the Northern West African margin revealed that the unconformity located within thick clastic turbidite deposits at the Coniacian-Santonian boundary (~85Ma) also constitutes a petrologic discordance of key significance for the hydrocarbon exploration in the area. Analysis of petrographic samples from selected reservoir facies in seven wells drilled in offshore Sierra Leone and Liberia indicate that a sharp change in sandstone reservoir quality occurs at that surface. Above the C-S unconformity, Santonian and younger sandstones are arkoses characterized by well-preserved detrital K-feldspars and plagioclase grains, incipient quartz overgrowths, moderate amounts of diagenetic kaolinite, and good intergranular porosity, thus constituting reservoirs of good to excellent quality (phi=15-35%, K=10-1000 mD). But right below the C-S unconformity, arkoses of Coniacian and older ages exhibit a combination of deep diagenetic processes (> 100-130°C) such as pervasive feldspar dissolution, feldspar kaolinitization and/or albitization, increased quartz cementation, kaolinite-to-dickiteto-illite transformation, illitization of I/Sm mixed-layer clays, and late Fe-carbonate cementation, that severely damaged their reservoir quality (phi=0-25%, avg K< 10 mD). Moreover, vitrinite reflectance breaks in depth trends, e-log kicks (e.g., in GR), increases in resistivity, sonic and/or density, and/or decreases in gas background while drilling clearly mark the change to poorer reservoir quality below the C-S unconformity. Much of the abrupt decrease in reservoir quality observed within the sandstones of the “albitized zone” can be explained by the pervasive kaolinitization of detrital feldspar grains, which is linked to the peak in quartz cementation related to the silica excess generated by the transformation. There is abundant detrital plagioclase being dissolved, while textural evidence suggests that some detrital K-feldspar grains probably survived dissolution, but later became totally albitized with depth. Several ions released in solution during these feldspar transformations would have precipitated as late patchy calcite or Fe-calcite which filled most of thealready scarce-remaining pore space. This massive process of feldspar kaolinitization could be explained by some mechanism of preferential fluid circulation and percolation along the Coniacian-Santonian unconformity and downwards. The origin of this unconformity is associated with some of the eustatic or tectonic events described in Western and Central Africa at the beginning of Late Cretaceous times. In this stratigraphic context, recognition of the C-S unconformity as a significant reservoir quality boundary may contribute not only to further age refinement of the event, but also to guide the search for hydrocarbons in the region.

FORMATION AND CYCLICITY OF NON-ANNUAL FE-MN LAMINAE IN LAGO FAGNANO, TIERRA DEL FUEGO

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Lago Fagnano, at 54°S in Tierra del Fuego (Argentina/Chile), is the southernmost ice-free lake outside of Antarctica and, as such, a gateway to understand past and present relations between Antarctic, South Pacific and South Atlantic climate changes. Previous studies demonstrate that the sediments deposited in Lago Fagnano are a sensitive and rare recorder of past climate variability in the southern high latitudes. Strong westerly winds impact Lago Fagnano the whole year and cause lake mixing especially during austral summer. However, the sediments exhibit a cyclic alternation of light clay and dark green to black laminae suggesting a well-stratified lake under certain weather or climate conditions. As yet the causes and cyclicity of laminae formation in Lago Fagnano are unknown.

Here we used thin section microscopy, µXRF elemental scanning and mapping, SEM and XRD analyses measured on sediment cores to explain the sediment lamination in Lago Fagnano. Two types of lamination are observed during the Holocene: (1) a coarse, cm-scaled lamination (type-1) in the western sub-basin is characterised by a very low sedimentation rate of ~0.2 mm/year and a cyclicity of ca. 42 years. (2) A fine, mm-scaled lamination (type-2) is observed in the eastern sub-basin of the lake, where sedimentation rate is somewhat higher (~0.4 mm/year) and light-dark laminae-couplets are more frequent (on average every ~5 years). Light laminae are mainly composed of clay minerals, quartz and feldspars, delivered to the lake by runoff, whereas dark laminae show elevated Fe, As and sometimes S values. Iron is by far the dominant element and mostly detrital, but authigenic Fe-oxides have formed as well in the dark laminae. Manganese is identified as (1) Mn-oxides within the light layers (coarse lamination, type-1), or (2) together with Fe in the dark laminae (fine lamination, type-2).

Based on these observations and similar results of studies from other comparable lacustrine settings (e.g. Lake Baikal), we propose the following conceptual model for the laminae formation and preservation in Lago Fagnano: (i) under well-oxygenated and oligotrophic lake conditions, a low sedimentation rate and deep penetration of oxygen into the sediment leads to the migration of reduced Fe and Mn towards the oxicanoxic sediment interface and accumulation as Fe-and Mn-oxides. (ii) A rapid increase of sedimentation (due to higher runoff or mass wasting events), or decreased oxygen penetration due to stratification of the water column promote the burial of the oxidised Fe-Mn lamina. (iii) Once a redox boundary has been established again, a new Fe-Mn lamina will be accumulated. The cyclic repetition of these buried layers every ~42 and ~5 years in the western and eastern subbasins, respectively, during the Holocene, suggests a forcing mechanism related to climate oscillations, potentially the Antarctic Oscillation and/or El Niño.

STRUCTURES AND MOVEMENTS OF LARGE SUBMARINE TIDAL DUNES IN THE ST. LAWRENCE ESTUARY (CANADA)

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Submarine dune fields are important morphological features of estuaries and continental shelves. Their existence and characteristics depends upon the grain size and the current strength. The St. Lawrence River discharges 12000 m^3/s through the St. Lawrence Estuary into the Gulf of St. Lawrence (eastern Canada). The Upper St. Lawrence Estuary (USLE) between Quebec City and Tadoussac is characterized by several sills and basins, between 30 and 150 m depth. The USLE is 160 km long, 20 km wide with a tidal range of 6 m and strong tidal currents up to 4 m/s. Sediment grain size in the USLE varies from mud to boulders, depending on local currents. Holocene marine clay deposited when relative sea level was 50-120 m higher.

The morphology of dune fields was surveyed with a Kongsberg Em^2040 multibeam echosounder operated at 300 kHz. Data were recorded on the RN Coriolis II in September 2013, September 2014, September 2015 and early October 2016. Surface sediments were collected with a Van Veen grab sampler. Numerous dune fields exist in the USLE, covering up to several square kilometers each. Most are large dunes, with heights between 2 and 8 m, wavelengths between 60 and 250 m, and mainly 2-dimensional shapes. Superimposed small dunes (wavelength about 5 m) arc often visible in the multibeam backscatter intensity or on side scan sonar records. Grain size varies from medium sand to coarse sand with some gravel, depending on the dune field. Dunes are generally asymmetric, and both ebb-and flood-dominated dunes have been observed. Most dunes are flood-dominated with upstream migration due to estuarine circulation, except in the uppermost part of the USLE, where water depth is less than 20m and the water column well mixed.

The Île Blanche dune field (47°59' N 69°35' W), covering 4.6 km^2, was surveyed in four consecutive years. Dunes are 3-6 m high with a wavelength of 60-100 m. Near bed currents estimated from the STLE400 numerical model are 0.8 m/s during spring tide. Migration rates are about 39 m/year toward SW (upstream) in the southern part of the dune field, without significant interannual differences. In the northern part, migration rates are 45 m/year in the opposite direction toward NE (downstream). The opposing migration directions observed in different sectors of the dune field reflect the flow divergence between the north and south channels of the USLE.

Further upstream, the Île-aux-Coudres dune field (47°28' N 70°15' W) is in a narrowing of the main channel in 50 m depth, where near bed currents during spring tide are 1.3 m/s. The dunes are larger, up to 9 m high, covering 11 km^2, and are composed of coarse sand with some gravel. Migration rates are 10-20 m/ year upstream. The extent of dune fields in the USLE is controlled mainly by current velocities, i.e. dunes fields are absent in shallower areas of the main channel where currents are too strong.

IMAGING AND CHEMICAL SIGNATURES OF SANDSTONE CEMENTED BY CALCIUM-SULFATE, IN THE STIMSON AND MURRAY FORMATION ROCKS OF GALE CRATER, MARS

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After the Curiosity rover reached the lower slopes of Aeolis Mons (informally, Mount Sharp), primarily lacustrine mudstones of the Murray formation were observed. Their particle sizes are commonly below the spatial resolution limits of the cameras aboard Curiosity (very coarse silt or less). After arriving at the Murray Buttes, sandstones, with very fine to fine sand, were identified using the Mars Hand Lens Imager (MAHLI) images. Supporting evidence for intra-Murray formation sandstones come from observations made using the ChemCam Laser Induced Breakdown Spectroscopy (LIBS) grain size proxy (e.g. RiveraHernandez et al., 2017 EGU) and Remote Micro Imager (RMI) images. Another feature of the upper Murray formation is the occurrence of light-toned materials approximately parallel to bedding planes. MAHLI images provide first order confirmation of the grain size of these light-toned rocks. Some of these sandstones have a speckled light toned appearance in MAHLI images, suggestive of pore-filling Ca-sulfate cement. The ChemCam observations provide an independent indication of the presence of Ca-sulfate cemented porous sandstone within the Murray formation and light-toned bedding plane materials. Throughout the entire ~17 km rover traverse through ~300 m of stratigraphy, calcium sulfate veins are common and ChemCam LIBS analyses show that these have a distinct composition with ~40 wt% CaO. However, in the Murray sandstone we began finding CaO abundances for average rocks between 15 and 25 wt%. Additionally, the signature of these intermediate-CaO occurrences are distinctive in the shot to shot data of each observation point, as the intermediate composition is consistent across the 30 laser shots. In poorly sorted sandstones as observed here, typical porosities can vary between 5% to 30% by volume up to ~30% by volume, and therefore CaO abundances around 15-25 wt% are consistent with a cemented sandstone, regardless whether the cement is from late diagenetic fluids or due to evaporitic conditions. The first significant detection of Ca-sulfate cemented sandstone, with CaO abundances exceeding that of the silicate component, was documented in Stimson formation rocks at Marias Pass by Newsom et al., 2016, LPSC. In that case, as with later ones, the elevated CaO and evidence from MAHLI and RMI images supported the identification of a Ca-sulfate cement. Other lithology changes in the Murray rocks at the Murray Buttes include an increase in the variety of sedimentary structures including a heterolithic mudstone-sandstone assemblage of facies that includes laminated, wavy/irregular/crosslaminated or cross-bedded layers with clear geometric truncations, and an increase in the Chemical Index of Alteration (CIA) (e.g. Mangold et al. this meeting). Among the differences between middle and lower Murray formation rocks, is the observations of a layer containing mud cracks in the middle Murray formation documented by Stein et al. (2017 LPSC). These observations indicate a change in the depositional environment and/or provenance of the Gale lake deposits as the rover proceeds into higher stratigraphic levels of the deposits (e.g. Stack et al., this meeting).

SEDIMENTARY DEPOSIT OF MEANDERING PALEO-CHANNELS ON THE MUN RIVER FLOODPLAIN FROM ERT SURVEY, KHORAT PLATEAU, NORTHEASTERN THAILAND

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At the upstream part of meandering system, the Mun River flows through Mesozoic clastic sedimentary rocks on the Khorat Plateau, northeast part of Thailand. A massive amount of sand was transported by this river until it joins Mekong River. From the 1974-aerialphotographs interpretation, the diversified and various size of paleo channel were distributed along both of the Mun River floodplain. The data from the primary work obtains only the surficial, but the geophysical survey lead to understanding of the channel geometry in the subsurface which can provide the understanding about fluvial process in the past. Therefore, we aimed to understand the evolution of fluvial system from shallow geophysical methods and sedimentary survey by drilling the borehole for describing subsurface morphology and sedimentology of ancient and modern channels, pointbar and floodplain. We applied Electrical Resistivity Tomography (ERT) to characterize the lateral and vertical morphology of paleo-channels. This method was interpreted together with on-sites boreholes to describe the physical properties of subsurface sediments and defined the exact boundary between in-channel and floodplain sediment. As a result, we concluded that the meandering rivers with channel-filled sequence and floodplain were detected from ERT profiles. Channel geometry is approximately 30 m wide and 5 to 10 m depth. Point bar deposit shows moderated to high resistivity from inversion model (100-1200 Ω.m) and it associated with loam and clayey to silty sand. High resistivity value (100-160 Ω.m) was interpreted as channel sediment deposit at. Borehole data are involved in loam and clayey to silty sand. On the other hand, silty to sandy clay and clayey silt deposition conforms to low resistivity value (0-20 Ω.m), and it is applicable for floodplain deposit. The changes in resistivity correspond well with differences in particle size and show relationship with ERT lithological classes. Clay, silt, sand, loam and bedrock were classified by the resistivity data. Geometry of paleo-channel embayment and lithological differences can be detected by ERT.

SEDIMENTARY EVOLUTION OF CHUTANI FORMATION, SAN PABLO TIQUINA SECTION

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Chutani Formation (Kungurian-Lower Triassic) of NE Tiquina strait are mainly composed by limestones (mudstone, wackstone and packstone) with various skeletal (brachiopods and bivalves) and nonskeletal (ooids and intraclasts) and limestones. This mainly facies analysis has recognized 5 associations from low to high-energy environment, including barrier, lagoon, flood tidal, dunes and foreshore with a possible volcanic provenance. (1) Barrier facies (calcareous sands) upward with an increase of high energy to the top. (2) Lagoonal Facies (mudstone and marls) contain regular preserved brachiopods and bivalves interpreted in a shallow subtidal environment but protected by sandstones shoals. (3) Flood tidal (intercalation between sandstones and clay) where commonly alternating layers of both textures where some plants are observed and they could have played a significant role on the environment. (4) Eolian dunes (sandstones), presents upward sequences with crossed stratification due to the action of waves. (5) Foreshore facies with volcanic with volcanic source, as indicated by presence of tuffs and fine grained volcaniclastic sandstones (probably re-transported as pyroclastic deposits), and by basaltic lavas overlying Chutani Formation in transition with red beds of Tiquina Formation. This section can be connected within the development of an early regional rift process associated regionally with the hyposaline units as Upper Permian fluvial and eolian volcaniclastic units described by Sempere et al., in 2002, that had been associated with the restricted environments with Glossopteris record both in arid and humid conditions in transitional to continental basins. This work establishes a correlation of depositional sequences in the section showing a relatively shallow and deep marine (barrier, lagoonal, flood tidal, dunes and foreshore with volcanic input) conditions dominated and associated with a semiarid tidal flat with mixed carbonate and siliciclastic sedimentation.

ANALYSIS OF MICROFACIES AND DIAGENETICAL EVOLUTION FROM CHUTANI FORMATION IN THE NORTH ALTIPLANO BOLIVIA

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Microfacies analysis and diagenesis in carbonates of the Chutani Formation (Titicaca Group), outcropped in the San Pablo de Tiquina town south east of LakeTiticaca, La Paz Departament, pretend to contribute to the understanting of diagenetic evolution during the late Permian. Chutani Formation constituted by calcareous sandstone, limestones (mudstone and wackstone totally and partially dolomitized), and intercalation with marls lies in concordance on the well-known Copacabana Formation. Paleontological elements would indicate an association of fossil plants: *Glossopteris, Pecopteris* and *Asterothecase* at the top part of said unit similar to floras in Brazil y Argentina of late Permian age. The stratigraphic section was measured and the description includes; stratigraphic thickness, structures, contacts and paleosols. Sequential analysis has allowed us to identify six successions sedimentary (SF1-SF6); SF1, facies of calcareous sandstone with level alternation of mudstone and siltstone; SF2, calcareous mud or mudstone interbedded with levels wackstone, marls and calcareous sands; SF3, facies of marls with levels calcareous sands; SF4, facies of sandstones with arkose sandstone levels; SF5, facies of alternate mudstone with volcanoclastic levels, marls, calcareous sandstone; SF6, mudstone facies and calcareous sandstone levels. The twenty-seven selected samples from stratigraphic succession allowed to establish by petrographic description and cathodoluminescence various diagenetic procceses such as micritization, dissolution, dolomitization, dedolomitization y recristallization. Being the first and third the most accentuated for the base of sequence. Likewise, the fenestral, fracture and breccia porosity are present in the large part of the samples.

STRUCTURE AND TECTONIC EVOLUTION OF NARROW AND ASYMMETRIC CONJUGATE PASSIVE MARGINS: EXAMPLE FROM THE SOCOTRA-SHARBITHAT SEGMENT (EASTERN GULF OF ADEN)

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One of the current challenges in passive margin studies is about clarifying how rifting processes evolve in time and space to lead to the formation of passive margins. In the various crustal domains that compose the magma-poor margins, which tectonic structures and thermal processes are responsible for the crustal attenuation? What are the factors influencing the 3D geometry of the conjugate margins as the deformation localized towards the future breakup area? The main purpose of this contribution is to bring new constraints to the thinning and breakup mechanisms that occurred during the Gulf of Aden oblique rifting. This N75″E-trending young oceanic basin is oblique to the divergence (~30°N) and separates the Somalian plate from the Arabian plate.

We focus our interest on the unexplored Socotra-Sharbithat segment, extending from Socotra-Hadbeen (SHFZ) and the eastern Gulf of Aden fault zones (EGAFZ), between the Socotra island (Yemen) and Southeastern Omani margins. Based on bathymetric, magnetic, gravimetric data and single-/multi-channel seismic reflection data we provide: (i) detailed onshore-offshore stratigraphic correlations; (ii) new structural maps reflecting the spatial evolution of the various crustal domains (necking, hyper-extended, Ocean-Continent Transition (OCT) and oceanic domains) and the oblique accommodation zones; (iii) reconstructions of two representative onshore-offshore cross-sections across the conjugate margins.

The most striking results are the narrowness, the asymmetry and the significant segmentation of the Omani and Socotra magma-poor margins. From proximal to distal margins, our study reveals: (i) sharp necking domains (< 40 km wide); (ii) narrow hyper-extended domains (< 80 km) affected by volcanism; (iii) exhumed domains affected by volcanism and formed by multiple detachment faults allowing the unroofing of serpentinized mantle and associated to several volcanic events; (iv) a complex proto-oceanic crust.

During the rifting (~38 – 17 Ma), the asymmetrical architecture of the margins seems to be triggered by the migration of rift center in the hyper-extended domain and the lower crustal flow that accommodates most of the extension (depth-dependent extension). The inherited Hadibo transfer zone develops during the early stretching phase (Upper Priabonian–Chattian Lower) and separates two major margin sub-segments.

The crust is attenuated along EW to N110°E-trending northward-dipping low angle normal faults developed under far-field stresses. We interpret the change in fault polarity in the northern margin hyper-extended domain as the result of mantle convections at the vicinity of the SHFZ. The exhumation phase (Burdigalian) begins with the separation of the upper plate (Oman) from the lower plate (Socotra) along a northward-dipping detachment fault. The unroofing of mantle is associated to decompression melting in the Omani hyper-extended domain. Finally, the proto-oceanic crust formation (~17.6 Ma) is triggered by the development of a final southward-dipping detachment fault in the exhumed domain associated to significant volcanism. Based on regional kinematic reconstruction, we discuss the influence of the shallowing of hot asthenosphere during the Oligo-Miocene rifting of the Gulf of Aden in the development of the Sheba ridge. We propose that mantle convection along the EGAFZ could have triggered the northwestward propagation of the eastern Sheba ridge towards the Socotra-Sharbithat segment.

TIMING AND CONTROLS ON THE DELIVERY OF COARSE SEDIMENT TO DELTAS AND SUBMARINE FANS ON A FORMERLY GLACIATED COAST AND SHELF

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The evolution of deltas and submarine fans is often envisioned as largely controlled by relative sealevel (RSL) variations. However, in some cases, RSL can have less effect on delta and submarine fan activity than sediment supply and shelf geomorphology. In order to document the relative importance of these three factors on deltaic and submarine fan evolution in a former glaciated environment, this paper documents the delivery of coarse sediment to the Laurentian Channel (eastern Canada). The well-constrained stratigraphic and geomorphological framework of both the glacio-isostatically uplifted deltas and the modern Laurentian Channel fans allow to document and contrast the evolution of riverfed deltas, river-fed canyon/fan systems and longshore drift-fed fans during deglacial and postglacial times. The evolution of these different types of fans can be divided into three phases. The first phase is characterized by delta progradation on the shelf while RSL is at its maximum and the ice-margin gradually retreats inland. The second phase is characterized by the delivery of deltaic sediment in the deep realm of the Laurentian Channel, permitted by the supply of important amount of glaciogenic sediments derived from the retreating ice margin and the lowering of the RSL. At the same time, sediment instability along the steep Laurentian Channel forms small incisions that evolve into submarine canyons where the narrow shelf allows the trapping of longshore sediment. The third phase is characterized by the withdrawal of the ice-margin from the watershed of the main rivers and the drastic decrease in sediment supply to the deltas. Consequently, the delta fronts experience strong coastal erosion and the eroded sediments are transferred on the shelf and to adjacent bays. This transfer of coastal sediments allows the continued activity of longshore drift-fed canyons. The retreat of the ice margin from the watersheds thus controls the supply of sediment and induces a change in delta type, passing from river-dominated to wave-dominated. This paper highlights the role of the type of sediment supply (ice-contact, glaciofluvial and longshore drift) in the timing and activity of submarine fans in high latitude environments. It proposes a conceptual model for high-latitude shelves where sediment delivery to submarine fans is mostly controlled by structural inheritance (watershed area and shelf geomorphology) rather than RSL fluctuations.

NEW EVIDENCE FOR A LATE-QUATERNARY GIANT SUBMARINE LANDSLIDE ON THE EXTERNAL WEST LEVEE OF LAURENTIAN FAN

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The Laurentian Fan is one of the largest submarine fans on the western margin of the North Atlantic. Recently acquired high-resolution multibeam bathymetric data (60 m horizontal resolution) reveal an extensive mass transport deposit (MTD) on the west levee of Western Valley, covering > 14,000 km^2 in water depths from 3900 m to > 5000 m. Typical MTD features are observed such as headscarps that often reach the crest of the levee, crown cracks, extensional ridges, blocky debris and flow lineations. Multiple headwalls are observed on 3.5 kHz sub-bottom profiles indicating that the MTD retrogressed upslope. While the upper parts of the MTD consist of intact blocks that were displaced downslope as ridges and troughs, the lower part exhibits ca 30 m thick of incoherent to transparent acoustic facies typical of debris flows. Landslide geomorphology thus suggests that it was generated as a retrogressive spread or slump and that slide blocks disintegrated downslope to become a debris flow. The debris flow extends downslope ca 90 km and partially fills a submarine channel. The superposition of the debris flow filling the channel and the location of the MTD at the top of the stratigraphic succession in the levee suggests that it is late Quaternary in age, possibly Holocene. Deeper seismic reflection data also show that this event is unique during the Quaternary; no other large-scale MTDs are observed in the upper ca 375 m of the levee succession.

THE INFLUENCE OF DOWNSLOPE AND ALONGSLOPE PROCESSES ON DEEP-WATER SUPERCRITICAL FLOW BEDFORMS (EASTERN CANADA)

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The Gully is the largest submarine canyon on the western North Atlantic margin. On the Scotian Slope and rise (Eastern Canada), the outer Gully canyon system merges with other submarine channels, generating a wide range of sediment waves. Large-scale crescentic bedforms, bedforms on levees and oblique bedforms on open slopes reveal the behaviour of turbidity currents and its influence on the formation and location of sediment waves. Crescentic bedforms, interpreted as net-erosional cyclic steps, are located where flow stripping occurs, indicating powerful flows eroding the seafloor. Net-depositional cyclic steps are located on the levee of channels, where depositional processes are greater than erosional processes. In contrast, antidunes are oriented obliquely to the main turbidity current downslope direction, indicating that the flows responsible for their presence are deflected due to contour currents that can be up to 0.4 $m.s^{-1}$ in the area. The contour deflected turbidity currents consist of the low density component of the main turbidity current, which is reflected in the type of bedforms observed. The location of the cyclic steps and antidunes thus reveals the relative influence of downslope vs alongslope processes on bedform formation in a mixed turbiditecontourite system.

SEDIMENTOLOGY AND MAGNETOSTRATIGRAPHY OF THE CRETACEOUS FORMATIONS IN THE HAMAKOUSSOU AND MAYO OULO-LERE BASSINS IN THE NORTHERN CAMEROON (BENUE THROUGHT)

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The Hamakoussou and Mayo Oulo-Léré sedimentary basins of Cameroon are extensions of the active branch of the East-West Yola Benue Trough, whose formation is related to the opening of the South Atlantic from the dislocation of Gondwana. An age range of Early Cretaceous to the Hauterivian Barremian boundary has been assigned based on biostratigraphy. The sedimentary sequence in both basins is composed of upward fining fluvial to fluviolacustrine deposits. The deposits present an alternation of fine grained sandstone, siltstone and mudstone overlying coarse sandstone which is underlain by conglomerate facies at the base.

A magnetostratigraphic study has been carried out on a succession of fine-grained sediments in the upper part of each sections. Specimens subjected to progressive alternating field and thermal demagnetization show that the sedimentary sequences have a primary magnetization. The directions of magnetization indicate a later regional tectonism marked by a rotation and translation block. Rock magnetic investigations reveal the presence of both high and low coercivity minerals. A sequence of three polarities was determined along each section of the Hamakoussou basin: one reversal polarity and two normal polarities, whereas two polarities: (normal and a reversal) were determined along Mayo section in the Mayo Oulo-Lere basin. The rate of sedimentation was determined, numerical ages were attributed to the formations studied and the time of establishment of the two basins studied was deduced.

THE EKITALE BASIN (NORTHERN TURKANA DEPRESSION, EARS, KENYA): AN EXAMPLE OF MICRO-BASIN CHARACTERIZING THE INITIATION OF CONTINENTAL RIFTING ?

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Nature and evolution of basins during early phases of continental rifting remain poorly documented mainly because most of the related deposits lie at deepest part of basins and thus rarely outcrop at the surface. As a consequence, the precise mode of creation of depocentres during the initiation of continental rifting and the nature of their sedimentary infill have been only sparsely observed and documented.

Here, located on the Western rift shoulder of the North Lake basin, a newly identified sedimentary basin is documented in the Turkana Depression (East African Rift System, Kenya). This basin is referred to as the Ekitale basin and is filled by the ~75 m thick Topernawi Fm. The preserved portion of the Ekitale basin is 3 – 5 km wide graben, bordered by N40-50° normal faults inherited from the reactivation of a basement inherited fault zone. The Topernawi Fm is dominated by clastics rocks, the lower part of the Topernawi Fm records the evolution of a lake that was bordered by alluvial fans and fed by a mature fluvial system that entered the lake and generated extensive mouth deposits. In the upper part, sedimentation is dominated by pyroclastic deposits repeatedly reworked by fluvial processes. Subsequently, the Ekitale basin was inverted and then abandoned due to the opening of the North Lake basin and the activation of the general N-S oriented faulting at the origin of the present-day configuration of rift basins in the area.

The Ekitale basin is younger than 28 Ma (final age of the underlying Turkana Volcanics Fm) and older than 14 Ma (age of a dyke crosscutting the Topernawi Fm). It is attributed to the evolution of an early syn-rift micro-basin and the development of such early syn-rift micro-basins is considered to characterize the initial stage of the surface rupture during the Cenozoic rifting in the northern Turkana Depression. This stage is assumed to have originated from a low differential stress that favored the reactivation of non-optimal inherited faults in a period that postdates the pre-rift condition characterized by no stress and predates a stage associated with high differential stress at the origin of oriented rift basins.

In this contribution, the Ekitale basin and the Topernawi Fm are illustrated in details. A geological map is provided delineating both the main sedimentary units and the structural features based on field observations and correlations. Four basin-scale transects display the current architectural configuration. Depositional processes are analyzed in order to provide the successive depositional environments. Then, tectonic structures and the elative chronology for their emplacement are proposed. Finally, a model for the tectonosedimentary evolution of the Ekitale basin is exposed, integrated in the rift history of the northern Turkana Depression.

SEDIMENTARY EVOLUTION OF THE PALEOLAKE TISSINT (ANTI-ATLAS, MOROCCO): IMPLICATIONS FOR "FEIJAS" DYNAMICS AND CLIMATE EVOLUTION IN NORTHWEST AFRICA BETWEEN CA. 75 AND CA. 10 KA

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The Anti-Atlas mountain range (southern Morocco) is drained southwards by several regularly spaced rivers, all tributaries to the Oued Draa, which constitutes the main fluvial system in southern Morocco. Between the southward front of the Anti-Atlas and the escarpment of the Jbel Bani, these rivers leave narrow valleys and feed extensive 1 km to 15 km lowlands locally called "Feijas". These lowlands are due to the differential erosion of rocks of the Cambrian and Lower Ordovician in comparison with rocks of the Precambrian and Upper Ordovician. They corresponded to important depocentres during the Quaternary as revealed by their significant deposits made of alternating alluvial, fluvial and lacustrine sediments. Although these deposits have been identified for a long time, detailed sedimentological characterization was never carried out.

In this project, the "Agadir-Tissint Feija" is characterized sedimentologically using facies and sequence analyses. In addition, an extensive sampling of carbonate deposits in this sedimentary succession allowed establishing a robust U/Th-based age-model. The sedimentary succession of the "Agadir-Tissint Feija" is 16 to 27 m thick and was deposited between ca. 75 ka to ca. 10 ka. Based on facies analysis, the sedimentary succession is divided into two units. The lower unit consists of 11-12 m thick lacustrine-dominated sediments revealing a relative long-lasting paleolake referred to as the "Paleolake Tissint". The upper part is a 5-15 m thick fluvial-dominated interval in the form of flood plain sediments. "Paleolake Tissint" was a shallow carbonate lake that developed during wet conditions through the pulsed buildup of travertines that repeatedly created a sill at the outlet of the depression. The lake was characterized by low-energy vegetated shores, productive lake margins and a low-energy basinal portion. Two successive asymmetric sequences are observed within the "Paleolake Tissint" infill, both showing a rapid flooding followed by a slow subsequent regression. Each of the lacustrine sequences is overprinted by a second-order periodicity induced by higherfrequency lake-level fluctuations.

In this contribution, we interpret the sedimentary facies, present the sedimentary evolution of the "Paleolake Tissint" and its genetic relationship with the sill buildup. Finally, we discuss each periodicity in lake level fluctuations with regard to climate mechanisms that generated wet-dry alternations in this part of Africa. Because the sedimentary evolution of the "Agadir-Tissint Feija" is considered as representative to other "Feijas" in southern Morocco, we argue that these systems constitute valuable new archives for Late Quaternary paleoclimate in Northwest Africa.

AN INTEGRATED APPROACH TO CHARACTERIZATION AND DIAGENETIC MODELING OF A LATE ORDOVICIAN RESERVOIR, MAMUNIYAT FORMATION, MURZUQ BASIN, LIBYA

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The diagenetic characterization of the sandstones in a field located in central Murzuq Basin (Libya) has been studied in order to evaluate its reservoir quality. Sandstones were sampled from full cores of the Mamuniyat Formation (Late Ordovician), considered one of the largest hydrocarbon glaciogenic reservoirs in North Africa. Due to feldspar dissolution, present time quartzarenites can be classified as subarkoses when the original detrital modes are reconstructed. Low values of calculated intergranular volumes (IGV), together with the increasing compactional porosity loss (COPL) with depth confirm a high degree of compaction. Regarding cementation processes, quartz as grain overgrowths constitutes the main cementing phase, whose distribution cannot explain the observed variations in reservoir quality. Petrographic observations indicate that major compactional processes took place before the onset of any cementation process. Feldspar kaolinitization, pore-filling kaolinite cement and minor secondary porosity generation by grain dissolution are associated to a late phase of uplift (Austrian event) and they play a subordinate role on porosity and permeability preservation. The relative timing of the oil-bearing fluid inclusions allows recognizing three pseudo-pulses of hydrocarbon migration. A retardation effect on quartz cementation due to hydrocarbon presence is needed to explain the observed preservation of primary intergranular porosity. A detailed seismostratigraphic analysis shows the inverse relationship between burial depth and porosity and permeability, thus making differential compaction the main diagenetic driver for reservoir quality. Sandstones with higher IGV and relatively lower COPL are associated to lower values of seismic impedance and good reservoir quality characteristics, whereas sandstones with lower IGV and higher COPL are associated to higher values of seismic acoustic impedance and tight characteristics. The reconstruction of the diagenetic path of the sandstones has been modeled using TouchstoneTM software. The diagenetic model integrates petrophysics, sedimentolology, and sequence stratigraphy to honor the evidences of hydrocarbon migration as well as the regional basin model of the area and seismic attributes. This integrated model explains how the diagenesis affected the distribution of porosity and permeability in the studied area.

PLAY CONCEPTS OF THE UPPER PALAEOZOIC AND MESOZOIC SUCCESSIONS IN THE GREATER BARENTS SEA BASED ON KEY SEQUENCE STRATIGRAPHIC SURFACES

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The Greater Barents Sea, an Arctic frontier area, has multiple proven play concepts and petroleum systems within the Devonian to Lower Cretaceous sequences. So far economic discoveries are only related to Upper Carboniferous–Permian carbonates (the Prirazlomnaya field), Triassic alluvial and paralic sandstones (the Goliat field) and lower–middle Jurassic shoreline sandstones (the Snøhvit field). Additional large discoveries, however, occur in several stratigraphic levels in the Permian to Lower Cretaceous successions implying a future prolific petroleum province. The discoveries are clearly linked to key sequence stratigraphic surfaces which formed as responses to plate tectonic reorganisation, i.e., first order sequences, or more local or semi-regional tectonic events in the Arctic realm, i.e., lower ranked sequences.

Many of the sedimentary basins in the Greater Barents Sea, particularly the northern part, have limited geological and geophysical data coverage. Well known onshore geology, however, from Franz Josef Land, Svalbard, North East Greenland and Sverdrup Basin coupled with offshore subsurface data have made it possible to construct viable sequence stratigraphic subdivisions as a strong tool for de-risking play concepts. Mapping of subaerial unconformities (SU), maximum regressive surfaces (MRS) and maximum flooding surfaces (MFS) have been shown to be important for de-risking potential reservoirs and high organic rich shales.

The two upper Palaeozoic order sequences; Lower Carboniferous and mid Carboniferous to Upper Permian are mapped onshore as sub aerial unconformity surfaces and predict the presence of karstified porous and permeable carbonates offshore. Similarly, defining lower ranked sequences during high frequency sea level changes in the Upper Carboniferous and Lower Permian mixed carbonatesiliclasticevaporate succession is also important for successful play concepts.

The Mesozoic successions on the platform areas in the Barents Sea are subdivided into four first order sequences; 1) The Permian to Rhaetian wedge consists of mainly northwestward prograding deltas or shelf edge deltas in response to denudation of the Uralian mountain chain and northern Fennoscandia; 2) The Rhaetian to Bajocian first order sequence consist of paralic deposits which to date, host the most successful plays in the Southwestern Barents Sea; 3) A southwards prograding wedge of Bajocian/Bathonian to Late Albian age is mainly derived from uplift in the North caused by rifting and opening of the Amerasian Basin, but wedges also build out from internal basinal highs and basin margins and 4) the Cenomanian to Maastrichtian succession, but is to date an untested play in the western margin of Barents Sea Platform. These sequences are subdivided into regional correlative transgressive-regressive system tracts that are important for predicting plays. Regionally correlative sequence stratigraphic surfaces may reflect more local tectonics such as the North Atlantic Rift System and salt tectonics.

DEPOSITIONAL ENVIRONMENTS AND COMPOSITION CONTROLLING FACTORS OF COAL AND CARBONACEOUS SHALES DEPOSITS: THE MANNVILLE GROUP, WCSB (ALBERTA, CANADA)

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Coal deposits mostly form in tidal-deltaic and alluvial plains depositional settings. Their composition and distribution in the stratigraphic framework depend from the interplay among different factors, such as: the variation of the groundwater table level, the humidity rate, the type of vegetation, the transport processes and the sediment supply. In this work the different depositional environments where coal forms and their relationship with the basin geological dynamics and climatic oscillations are determined.

To achieve the objective proposed by this work, the Mannville Group coal-bearing strata were characterized, by means of petrographical and geochemical analyses. Maceral analysis defines the organo-facies association for the different coals and Rock-Eval and Elemental Analysis determine their geochemical signature. Petrographic indices were calculated, performing data on the environmental conditions of the peat where coal was formed.

According to these interpretation and previous literature data, seven sub-depositional environments for coal formation were defined: Terrestrial, Dry Forest, Wet Forest, Swamp Forest, Reed Moor, Limnic and Open Moor depositional environments. These environments formed in the alluvial to coastal-tidal plain and their depositional dynamics and environmental conditions are controlled by sea-level/groundwater table oscillations and transport/sedimentation processes. For each depositional environment the humidity rate, the terrigeneous input and the type of vegetation forming the peat were reconstructed.

The vertical and lateral superimposition of the environmental conditions of the peat are induced by high order climatic oscillations, which determine the shift of the coast line along the sedimentary profile, thus variation in the humidity rate, the type of vegetation and the fluvial to coastal transportation and hydrodynamic processes in the peat. The combination of these elements are expressed by the variation of the groundwater table level, which can be considered as the key factor determining the type and the quality of the organic matter formed in a peat.

CONTROL OF BASIN STRUCTURE ON HYDROCARBON CHARGE AND RE-MIGRATION: A STUDY OF THE PLAYS AND PROSPECTIVITY OF THE NORTH CELTIC SEA BASIN, OFFSHORE IRELAND

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Evolving basin structure has a key role in the charge and migration / re-migration of hydrocarbons. Results from series of basin models for the North Celtic Sea Basin display the control structural evolution has on the timing of hydrocarbon maturation, charge history, trap formation, sealing potential and hydrocarbon phase change. This work adds to previous published studies, based on 1D modeling, by generating 2D models, constructed using the PetroModTM software. Seismic data has been used to control the regional structural development, whilst integrated wireline logs and geochemical information obtained from wells, yields lithology, porosity and palaeothermal data. Available vitrinite reflectance data has been used to calibration the models to a present-day heat flow of 52 m W/m^2.

Results highlight how hydrocarbon maturation, generation and migration were affected by the Triassic and Late Jurassic rifting events, resulting in a complex charge history and trap modification through time. The Late Jurassic source rocks (Purbeck) attained peak maturation for oil in the late Cretaceous, whilst the Early Jurassic source rocks (Liassic and Toarcian) entered the gas window in the Early Cretaceous.

Analysis of the petroleum systems for deeper prospectivity suggests that there is potential to charge suitable reservoir facies if reservoir quality can be preserved. The results highlight how basin geometry has changed through time, due to multiple tectonic events, leading to modification of older traps. Hydrocarbon preservation risk is low for anticlinal structures but there is a high risk of hydrocarbon re-migration in fault dependent structures.

UNIQUE SPATIAL ASSOCIATION OF MUD VOLCANO AND SANDSTONE INTRUSIONS, WESTERN TURKMENISTAN

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The mud volcano and sandstone intrusions complex occurring in the Boyadag anticline, Western Turkmenistan, is the only well-documented example of co-existing, but not synchronous, mud volcanism and sand injection. Integrated field and laboratory evaluations investigate the spatial and genetic relations between the mud extrusion and the later sand intrusion. The rising of mud and hydrocarbons from the Oligocene Maykop Fm. fed the mud volcano after the exposure of sealing Lower Pleistocene units at the top of the anticline. A weakly-cemented sandstone dike and a pillar pierce the mud volcano deposits on the crest of Boyadag anticline. Two more dikes occur near the escarpment caused by a crestal normal fault. The main physical process that led to sand fluidisation is identified as the progressive increase in pore fluid pressure within the Pliocene Red Beds Fm. during a stage of reduced or null activity of the mud volcano, which was caused by the up-dip migration of hydrocarbons into the sandstone reservoir units within the Boyadag structural trap. The hydrocarbons generated in the source rock levels of the Maykop Fm., whereas the saline water involved in the sand fluidisation is mainly the connate water of the Pliocene Red Beds Fm. The pressure rise was responsible for the fracturing of the sealing units, already weakened by the crestal normal fault and the mud volcano feeding system. The sand intruded into sealing units and mud breccia deposits, also using the mud volcano conduit and the crestal normal fault as preferential pathways. During the present-day background activity, the outcropping sandstone intrusions provide high permeability pathways for continuous fluid leakage, precluding the re-establishment of high pressures in the reservoir.

QUANTIFYING AUTHIGENIC FE-PHASES AND THEIR FE-ISOTOPE SIGNATURES IN LACUSTRINE SEDIMENTS

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Minerals formed authigenically can provide useful information on the prevailing environmental conditions at the time of nucleation. Additionally, while growing, they can also record abiotic and biological processes taking place in the sediments. One of the main goals of the Towuti Drilling Project (TDP) is to reconstruct environmental and climate dynamics of the western equatorial Pacific region, requiring analysis of environmental conditions at the time of mineral deposition. However, some diagenetic processes can eventually overprint the original signature of the environmental conditions existing during deposition of the sediment.

Lake Towuti (Indonesia) is anomalously rich in iron. Run-off waters drain the strongly weathered ultramafic catchment and feed the basin with iron and other redox sensitive elements. Today, Lake Towuti is ultra-oligotrophic, S-depleted, and has anoxic bottom waters. However, previous studies focusing on the last 60 kyr sediments reveal water column mixing during dry periods, leading to the deposition of higher amounts of Fe(III)-phases as well as siderite.

Some authigenic Fe-minerals like magnetite or Fe-oxyhydroxides are sensitive to redox conditions and thus potentially record the redox state of water bodies and sediments through time. The eclectic assemblage of Fe-minerals of Lake Towuti suggest redox processes primarily controlled by climateinduced changes in water column mixing. Nevertheless, Fe-minerals could also have a detrital origin, which could bias the authigenic signature of the Fe-bulk.

Given the difficulty to differentiate the authigenic, diagenetic or detrital origin of Fe-minerals in Lake Towuti, we analysed elemental, mineralogical and isotopic indicators in a 100 m Quaternary sequence to track dynamics in paleoredox conditions of the water column. Concentrations of Fe and other elements were quantified using a sequential extraction procedure where extracts are proportional to the digested minerals. This method gives thus an indication of the bulk mineralogy of the sedimentary record. Along with the speciation of sequentially extracted-Fe, δ^{56}Fe analyses were performed in the different Fe-pools: Siderite, magnetite, Fe-oxides and Fe-oxyhydroxides. This dataset was further compared to conservative trace elements and Rock-Eval data to characterize the bulk sedimentary organic matter and better quantify the siderite contents.

Disentangling the various processes mobilizing iron (i.e. dissimilatory reduction, diagenesis, precipitation and dissolution of Fe-oxides) will be critical to define how Fe-fractionation relates to the dominant redox reactions taking place in this particular environment. And, consequently determine how authigenic phases translate redox reactions in this particular system.

EMPOWERING THE RESULTS OF CONVENTIONAL ROCK-EVAL ANALYSESSIDERITE MATRIX EFFECT CORRECTION FOR PALEOCLIMATE RECONSTRUCTION USING ORGANIC MATTER PROXIES

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Many Organic Matter (OM) proxies are frequently used to reconstruct past environments, paleoproductivity, sediment provenance and nutrient sources. Rock-Eval 6 pyrolysis (Technologies Vinci, RueilMalmaison, France) is commonly used in tandem with measurement of total organic carbon (TOC), mineral carbon (MinC), Hydrogen Index (HI) and Oxygen Index (OI). HI and OI indexes are respectively proportional to the H/C and O/C ratios of the Organic Matter (OM) and are widely used to characterize OM sources, its preservation in sediments and therefore contribute to paleoclimate reconstructions. High HI and low OI values indicate authigenicalgalproduction and/or an extremely well preserved OM under reducing conditions. Conversely, low HI and high OI indicate an allochthonous provenance of the OM and/or oxic conditions in the water column. However, previous studies brought to light the matrix effects of siderite during pyrolysis which can bias these results. We have empowered this apparent weakness of the method and used it to better estimate Rock-Eval parameters. Matrix effects induced by siderite overestimate the Rock-Eval OI. Because siderite decomposes between 485 and 520°C, CO_2 released within this analytical temperature range is calculated as CO_2 liberated by the cracking of long-chained OM. Recent investigations suggested a new approach to correct OI and MinC values in siderite-rich sediments. Rock-Eval pyrolysis was performed on sediments of Lake Towuti (Indonesia) to characterize the type and sources of the OM. Today, the lake is ultra-oligotrophic, S depleted, and has anoxic bottom waters. Its sediments are anomalously rich in iron since run-off waters drain the strongly weathered ultramafic catchment and feed the basin with iron and other redox sensitive elements. Previous studies focusing on the last 60 kyr sedimentary record reveal water column mixing during dry periods, leading to the deposition of higher amounts of Fe(III)-phases as well as siderite. OI values are usually between 10-600 mg $CO_2.g^{-1}$ C_{org}. OI values of Lake Towuti are anomalously situated between 70-1300. MinC values in the uppermost 60 meters are relatively low. However, the presence of siderite is confirmed all along the profile by mineralogical studies. Although TOC values are generally low (between 0.5 and 2%) several peaks above 4% have been measured at certain intervals. These high values are not consistent with and strongly differ from the current ultraoligrotrophic conditions of the lake. Taking into account siderite contents is crucial for a straightforward interpretation of the Lake Towuti Rock-Eval dataset as well as correcting the TOC percentages estimated by other methods. The latter can be very important when calculating other OM proxies depending on TOC (e.g., OI, biomarkers). We proposed corrected OI values (between 65-1000 mg $CO_2.g^{-1}$ C_{org}) that are positively correlated to the oxyhydroxide content of the sediments. Both features suggest oxic conditions, either by oxygen supply to the bottom of the lake during turnovers or by substantial detrital input from rivers.

POST-OROGENIC SEDIMENTARY EVOLUTION OF THE RETRO-FORELAND BASIN OF AQUITAINE (PRIABONIAN TO TODAY)

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The Mesozoic Aquitaine Basin (alternations through time of rifts and intracratonic to passive margin basins) is inverted during Cenozoic times to become the retro-foreland of the Pyrenees Mountain Belt. A lot of studies were carried out on the paroxystic phase of the retro-foreland activity, few paid attention on the latest – post orogenic – stage, the so-called “Molassic” periods. This can be explained by the monotonous facies distribution along poor outcrops with few dating available.

For a better understanding of the last stage evolution of both the Pyrenees and Massif central relief – and their consequences on the sediment routing system – we performed a stratigraphic study of the “Molassic” deposits and their marine equivalent, from the upstream part (Lannemezan area) to the distal part (Landais Plateau and Biscaye Bay abyssal plain). This study was mainly based on subsurface data, seismic lines and wells (industrial and BSS) provided by the BRGM and TOTAL. Wells correlation was based on the principles of stacking pattern calibrated in age and facies on cuttings and clabs. The seismic lines were interpreted using the principles of the shoreline trajectory and calibrated in age and facies on wells. This study is part of frame of the S2S project funded by TOTAL and the BRGM.

The main results are as follows.

(1) A sharp transition between continental and marine environments characterized by mixed carbonate-siliciclastic (clays and silts) platforms. The Bartonian to Priabonian shelves are reefal platforms with a major downward shift at the Bartonian-Priabonian boundary. The exact location of the Eocene-Oligocene boundary is unknown (ongoing biostratigraphic studies) but the time interval between the base Priabonian and the Rupelian eustatic maximum flooding is characterised by a nice lowstand (LNR) wedge followed by an aggrading highstand (HNR) wedge. The Late Rupelian is progradational agradational and the Rupelian-Chattian boundary is a major unconformity.

(2) Continental environments (Priabonian to Chattian) are made up of palustrine to carbonate lacustrine sediments passing to mixed to suspended-load rivers, local base level of conglomeratic alluvial fans located in the extreme inner part of the basin at the feet of the Pyrenees.

(3) A major erosion occurred in the Chattian (ongoing biostratigraphic dating for a more precise age) with present-day preservation of the Chattian in the inner part of the basin along the Pyrénées (500 to 1500 m-thick wedge). Chatiian sediments were partly removed by erosion in the western part of the Lannemezan Plateau area and are mostly missing along the Aquitaine Basin.

(4) Lower to Middle Miocene sediments (with the same facies than above) are quite thin (50 to 200 m – low preservation). They record a major fall in the subsidence pattern.

(5) A two phases major uplift of the Lannemezan and Ger Plateaus occurred during Serravallian and base Tortonian times sealed by weatherings and fluvio-lacustrine sediments (Orignac lignites)

(6) From Late Miocene to today, the Aquitaine Basin is a sediment transit zone with deposition on the Landais Plateau as thick siliciclastic prograding wedges.

VERTICAL EFFECTIVE STRESS INFLUENCES QUARTZ CEMENTATION IN SANDSTONESMYTH OR REALITY?

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It is well established that the development of shallow overpressure within sedimentary basins reduces vertical effective stress (VES) and inhibits mechanical compaction, thus preserving porosity and economic reservoir quality. However, the influence of vertical effective stress on chemical compaction ("pressure solution") and related quartz cementation in sandstones has been underplayed in many clastic reservoir studies that have favoured temperature as the key control on quartz cementation. These models suppose that quartz cementation is controlled by temperature-related precipitation kinetics and that the supply of silica is largely irrelevant. However, it is commonly considered that the main source of silica for quartz cement is from intergranular pressure solution, the rate of which is influenced by VES. This study is targeted at understanding the relevance of VES to quartz cementation by investigating shallow marine sandstones of the Upper Jurassic Fulmar Formation in the UK Central Graben. Samples have been chosen from upper shore-face sandstones from Clyde (30/17B), Elgin (22/30C) and Fulmar (30/16) fields. These sandstones are the same facies, but have had different VES-temperature histories. All are at maximum burial depth with present day temperatures and VES as follows: Fulmar 127oC & 30 MPa; Clyde 147oC & 40 MPa; Elgin 189oC & 10 MPa. Point count data from SEM-CL petrographic analysis show that sandstones from Elgin – the highest temperature and lowest VES sample set has a lower average quartz cement content (0.10 ± 0.03) than both Fulmar (0.11 ± 0.06) and Clyde (0.20 ± 0.03) when normalised to detrital quartz content. The occurrence of clay coatings and micro-quartz cannot account for the differences in quartz cement. Evidence from highprecision in situ oxygen isotope ($\delta^{18}O$) analyses across quartz cements shows ~ 2 ‰ range in measured $\delta^{18}O_{(cement)}$ values between early and late cement in Elgin. This suggests precipitation within a relatively narrow temperature window, perhaps 20°C. Since Elgin has been in the classic quartz cementation window (i.e. > ca. 80°C) for over 90 Ma, we suggest that chemical compaction at quartz-quartz contacts and related cementation has been limited by low VES/high pore fluid pressure through much of Elgin's burial history. This work has significant implications for understanding how overpressure and VES control porosity preservation in high pressure, high temperature (HPHT) reservoirs, and would aid the development of better reservoir quality predictive models for prospective deep HPHT reservoirs.

TRAVERTINE SPRING TOWERS AT THE HISARALAN GEOTHERMAL FIELD (SINDIRGI, BALIKESIR-NW TURKEY): DEPOSITIONAL AND GEOCHEMICAL APPROACHES

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Spring towers are one of the rarest and most spectacular depositional morphologies of travertine precipitation. The Hisaralan Geothermal Field, located to 25 km NE of the Sindirgi town, Balikesir, NW Turkey is located in elevations between 300 and 450 m on a SW-facing slope. In the studied area, the oldest units are ophiolitic rocks and limestone blocks within the Izmir-Ankara Flysch Zone. The Miocene volcanic rocks such as dacite-riyodacite rest unconformably on these bedrocks. Spring towers and associated travertine depositional morphologies directly precipitated on the Miocene volcanic rocks. Presently, most of the towers are inactive, in less number tower formation occurred only along the Serin stream to the west of the studied area.

The tower-forming hot spring waters are those of Na-HCO_3 type. Temperature, pH, EC and HCO_3 values of the hot waters range between 54 to 97°C, 6.55 to 8.13, 1125-1429 µS/cm and 470-640 mg/l, respectively. Almost of these hot waters saturated in calcite, aragonite and dolomite. Saturation indices are 0.01-1.43 for calcite, 0.04-1.33 for aragonite and 0.25-1.79 for dolomite. Some of the waters saturated in quartz with a range of 0.07 to 0.44.

The towers are up to 5 m in height and up to 4.6 m in width at the base. The vents, which took place at top of the towers, are circular, oval or lenticular in shape. The internal vent walls were covered by radial calcite crystals. The most dominated lithotype is crystalline crust travertine in the towers that is accompanied by the laminated travertine and microporous lithotypes.

The most common element in the travertine samples is Ca with 260643 to 394857 ppm. The Sr concentrations are between 11636 to 515.8 ppm. The highest Sr values were yielded from the recent and subrecent samples close to the springs. Ba change from 63 to 3434 ppm. The stable isotope values are -0.5 to -4.3‰ (V-PDB) for carbon ($\delta^{13}C$) and -23.6 to -11‰ (V-PDB) for oxygene ($\delta^{18}O$). The $^{87}Sr/^{86}Sr$ values are higher with a range of 0.710024 to 0.710396 that is resulted from rock fluid interaction. The negative carbon isotope values most likely imply the CO_2 contribution of magmatic origin. Based on the element and stable isotope data, the travertine spring towers were precipitated by deeply circulated hydrothermal waters.

CARBON ISOTOPE STRATIGRAPHY ACROSS THE TRIASSIC-JURASSIC BOUNDARY: A NEW GLOBAL $\delta^{13}C$ STACK FOR CORRELATION AND TRACKING CARBON CYCLE PERTURBATIONS

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The Triassic-Jurassic boundary (TJB) immediately follows the end-Triassic extinction event, which is one of the five major Phanerozoic mass extinctions. Similarly to the other four events, the TJB is also marked by one or more prominent carbon isotope excursions (CIE). Since their first recognition in three independent studies in 2001-2002, a large amount of data has been assembled which prove that CIEs are recorded in both terrestrial and marine boundary sections, marine strata of different depositional settings, and in both carbonate and organic matter. However, no systematic review of these data has been attempted to date, even though controversies persist in $\delta^{13}C$-based stratigraphic correlation, and the processes and causes of the underlying carbon cycle perturbations remain debated.

Here we address these issues using a compilation of a global $\delta^{13}C$ dataset from sections which span at least parts of the Rhaetian and Hettangian stages. Our underlying age model uses a modified version of GTS 2012, with a notable update concerning the age of the Norian-Rhaetian boundary, leading to a shorter duration of the Rhaetian. Astrochronology is used to provide additional estimates of durations of chronostratigraphic units. Correlation of the sections is achieved through an integrated web of independent ammonoid, conodont, radiolarian, foraminiferan and palynological biostratigraphies and magnetostratigraphy.

A synoptic view of the global $\delta^{13}C$ stack allows a critical assessment of the reproducibility and global or regional significance of previously identified CIEs, including a Rhaetian precursor CIE, the latest Rhaetian initial negative CIE, the main negative CIE at the TJB, and one or more positive CIEs in the Hettangian. Clearly, not all of the above CIEs are recorded uniformly in different substrates, environmental settings or paleogeographic regions, warranting caution in the use of $\delta^{13}C$ in chemostratigraphic correlation.

Overall, the new global compilation will contribute to a better understanding of the processes and causes of carbon cycle perturbations across the TJB. Features of the global stack are compared with the predicted effects of previously proposed mechanisms of volcanogenic CO_2 degassing, methane release, reduction of primary productivity, changes in shallow marine carbonate production, changes in the burial rate of organic carbon and other scenarios.

INITIATION OF STROMATOLITE FORMATION AT THE INTERFACE OF OXYGENIC-ANOXYGENIC PHOTOSYNTHESIS

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In modern stromatolites, mineralisation results from a complex interplay between microbial metabolisms, the organic matrix, and environmental parameters. In order to characterise mineralisation processes and products in an emergent (< 18 months) hypersaline microbial mat from the Cayo Coco Lagoonal Network (Cuba), this study combined several methods: biogeochemical (oxygen production and consumption, sulfide concentration and pH profiles, sulfate reduction activity), mineralogical (X-Ray diffraction and Fourier Transform Infra-Red) and microscopic analyses (Cryo-Scanning Electron Microscopy and Confocal Laser Microscopy) with measurements of metabolic activity (sulfate reduction and anaerobic respiration activities, physicochemical properties and abundance of extracellular polymeric substance).

While the nucleation of Mg-silicates is ubiquitous in the mat, the initial formation of a Ca-Mg carbonate lamina depends on (i) the creation of a high-pH interface combined with a major change in properties of the exopolymeric substances at the interface of the oxygenic and anoxygenic photoautotrophic layers and (ii) the synergy between two major players of the sulfur cycle, purple sulfur bacteria and sulfate-reducing bacteria.

The repetition of this process over time combined with upward growth of the mat is a possible mechanism leading to the formation of a stromatolite.

RAMAN SPECTROSCOPY, A BREAKTHROUGH FOR PROVENANCE STUDY OF DUST (1-5 MM): DOME B ICE CORE, EAST ANTARCTICA

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The polar ice sheets are invaluable archives preserving information about past climate changes and atmosphere composition. Deep ice cores from Greenland and Antarctica provide records of several climatedependent proxies allowing climate reconstructions at different time scales, among which greenhouse gases, atmospheric aerosol and aeolian dust. The mineralogy of dust preserved in the Dome B (77°05'S, 94°55'E, 3650 m a.s.l.) ice core was investigated using Raman spectroscopy. Dust in central Antarctic ice cores is clay to finest silt, the volume-size distribution of particles showing modal values around 2-2.6 µm at the Dome B site. Single detrital minerals of such a fine grain-size range are exceedingly difficult to determine, a task that to the best of our knowledge has never been accomplished so far. In order to meet this challenge, we have developed a new protocol for the preparation and analysis of particles between 1 and 5 µm in diameter, in a clean room at the EuroCold Lab and at the Laboratory for Provenance Studies of Milano-Bicocca University.

Raman spectroscopy allows us to adopt a new approach to paleo-dust source tracking, not only based on commonly used method, as Sr, Nd and Pb radiogenic isotope fingerprint of the mineral dust. This new approach is based on single-grain mineralogy, which allows the identification of the mineral species and of polymorphs as well, providing fundamental information about source areas and depositional environment.

The thermal drilled ice core, made during the 1987-1988 Austral season by the 33rd Soviet Antarctic Expedition, covers the last 30 kyr. The record thus encompasses the last glacial period, the Last Glacial Maximum (LGM), the deglaciation and the beginning of the Holocene. Four Dome B ice core samples from the LGM were selected, and the mineralogical fingerprint of dust particles was investigated.

Three slides were prepared for each sample, and more than 630 Raman spectra were collected and identified, including quartz, plagioclase, feldspars, phyllosilicates, pyroxenes and zeolites derived from granitoid, metamorphic or siliciclastic rocks, associated with biogenic marine aragonite and iron oxides probably derived from erosion of soil profiles. Our observations confirm southern South America as the most likely dominant dust source for Dome B during the LGM. The significant content of carbonates (mostly aragonite), along with microscope observations of diatom valves of marine benthic/epiphytic and freshwater species, suggest a contribution from the exposed Patagonian continental shelf and glacial outwash plains of southern Patagonia during the sea-level low-stand period of Marine Isotopic Stage 2. The proposed method demonstrates the applicability of single grain Raman counting to the 1-5 µm fraction, opening up a new frontier in future mineralogical studies of dust.

DENSITY SORTING OF SILICICLASTIC AND ORGANIC PARTICLES IN A CONFINED DEEP-MARINE MINI-BASIN (PEÏRA CAVA, SE FRANCE): IMPLICATIONS FOR FLOW HYDRODYNAMICS AND RESERVOIR QUALITY

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Quantitative microscopic analysis was conducted in vertical profiles of turbidite beds from the Eocene-Oligocene Peïra Cava deep-marine mini basin in SE France, in order to detect spatial trends in composition, size and shape of organic and siliciclastic grains that may be related to hydrodynamic particles sorting. The analysis was mainly focused on sheet-like confined beds, which can be traced throughout the basin and represent proximal to distal architectural elements. The essential mineralogy of around 33000 siliciclastic grains was quantified in 112 thin sections. Turbidite mudrock samples were also taken at regular intervals in the logged sections to quantitatively assess both lateral and vertical variation of the type, size and shape of more than 3000 organic particles.

The percentage of specific siliciclastic grain types in each bed indicates a downcurrent change in mineral abundance from the more proximal to the more distal parts of the confined sheet beds, expressed mainly by a decrease in mean quartz content and an increase in mean mica content. Mica grains also show shape variation to more platy shapes towards the more distal parts of the basin. The same trend is also observed for the organic particles. Proximal beds display larger, dominantly subrounded and sub-elongate particles. Particles from medial sections are finer and typically sub-angular, and sub-elongate. Distal sections show the smallest particles, typically sub-angular and elongate.

In order to additionally estimate the role of particle shape as a factor of hydrodynamic sorting, particle settling velocities were also calculated for quartz, mica and organic particles. Results indicate different hydrodynamic behavior of studied grain types from the proximal and the distal parts of the studied beds. In particular, organic particles and micas are characterized by lower settling velocities, at the more distal parts of the studied intervals.

The observed downcurrent variations in siliciclastic and organic particle composition and shape are interpreted as a result of hydrodynamic sorting, due to differences in the density and shape of the studied particle types. These variations may have multi-faceted implications for the hydrocarbon exploration of deep-marine systems. They probably indicate downcurrent changes in flow characteristics, e.g., from turbulence-dominated to hindered settling-dominated flow types. They are also likely to influence the diagenesis, porosity and permeability of potential turbidite reservoirs through enhanced compaction and carbonate cementation processes.

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TURBIDITE BED THICKNESS DISTRIBUTION AND FACIES CLUSTERING PATTERNS IN DEEP-MARINE CHANNEL-LEVEE, CONFINED SHEET AND UNCONFINED LOBE AND BASIN PLAIN SETTINGS: IMPLICATIONS FOR THE IDENTIFICATION OF DIFFERENT ARCHITECTURAL ELEMENTS

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Studies regarding the frequency distribution of turbidite bed thicknesses based on widely used statistical models, and the study of thickness clustering in turbidite successions represent modern quantitative approaches for analysing turbidite deposits and have been used as an additional tool to more traditional approaches, such as the application of descriptive turbidite facies models. Statistical evaluation of bed thicknesses is one of the methods which can be used as an aid interpretation of deep-water depositional environments, and may provide information on turbidite depositional pro-cesses, distribution and geometry. Field data were collected from classic outcrops of well-studied deep-marine systems with well-understood stratigraphic architecture, representing characteristic ex-amples of thin-bedded channel-levee, confined sheets and relatively unconfined lobe and basin plain depositional settings: the Rosario Formation (Up. Cretaceous, Baja California Mexico), the Grès d'Annot Formation (Eocene-Oligocene, SE France) and the MarnosoArenacea Formation (Miocene, NE Italy) respectively. Fieldwork involved extensive sedimentological logging of the turbidite successions and gathering of detailed bed thickness data from different architectural elements. Results for selected architectural elements in the studied deep-marine systems indicate a prevalence of lognormal distributions, with mixtures of different lognormal thickness populations for each element sampled. Thin-bedded channel-levee elements are characterized by 1-and 2-component, confined sheet elements by 2-component and lobe and basin plain elements by 1-to 3-component mixtures respectively. These components are mainly representing deposits of mainly low-and occasionally higher-density turbidite flows in the case of thin-bedded channel-levee sediments, deposits of low-and high/very high-density flows in the case of confined sheet sediments, and deposits of high-, low-and occasionally very lowdensity flows in the case of lobe and basin plain sediments. Several datasets are also shown to have power-law behavior only for their thick-bedded sub-populations. The majority of studied sections also exhibit non-random thickness clustering which is useful for a general discrimination between sampled architectural elements. Differences in the number, variance and proportion of observed lognormal mixture components along with the presence and lower thresholds of power law tails were used to create an architectural element classification table for each deep-marine system studied. A re-evaluated diagram for classification of architectural elements between different deep-marine systems based on the degree of thickness clustering and its deviation from the clustering of similar simulated datasets was also created refining previously proposed classifications. The present work constitutes an architectural elements differentiation approach which proposes a number of statistical criteria. The latter in combination with sedimentological criteria and the use of other types of data could be integrated with subsurface datasets in order to assist the identification of architectural elements in the subsurface, and to evaluate their reservoir potential.

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IS THERE ANYONE NEEDING A DEFINITION FOR NUMMULITE BANKS?

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The use of the term ‘nummulite bank’ is currently widespread in the scientific literature, so one could guess it refers to something well defined, according to the original definition given by Paul Arni in the mid 1960s. However, we noticed that even in recent articles the nummulite bank concept seems to be extended to any nummulite-rich bed, including the ones where the distinctive features of the banks are not visible at all (at least judging from the descriptions and illustrations provided). Moreover, it seems the authors usually do not care about reporting how they recognized the nummulite banks themselves.

An additional issue results from the original definition of nummulite banks, which is essentially qualitative and, when dealing with features that could be quantified, such as the A/B ratio of the nummulite tests or the relative abundance of one species in the assemblage, did not quantify the boundaries that could be traced between a bank and a non-bank facies.

Given the debate regarding the autochthonous vs. allochthonous origin of the nummulite banks is still active, and some new results are trying to clarify the mechanism underlying the deposition of these peculiar biosedimentary bodies, we retain a shared and clear, quantitative definition of the nummulite banks is needed. For this reason, we extracted from the original definition two features that are distinctive and that could be easily observed preliminarily on the field, even in non-optimal outcrop conditions: the A/B ratio and the dominance of one or two species of nummulite in the assemblage. Both could be then quantified on relatively small samples after simple laboratory treatments. We underline that the field observations alone are insufficiently reliable because of the non-uniform exposed surfaces and cannot be used to determine quantitative parameters. Anyway, the preliminary estimates on the outcrop allow to avoid the most obvious non-bank facies.

We tested our assumptions on different examples of banks and non-banks from Germany, Italy, Romania, and Spain. On the collected samples we determined quantitatively the taxonomic composition of the nummulite assemblages and the A/B ratio. The results allowed us to clearly distinguish banks and non-banks and to set the boundaries quite easily.

According to the parameters we determined for nummulite banks, we realized that on the material collected in Adelholzen (Germany) we can recognize an ‘assilina bank’, which in our knowledge has not been reported since. This new achievement further demonstrates the potential of the proposed quantitative definition of the ‘banks’.

SHELLS AND SHELL FRAGMENTS AS MODIFIERS OF SEDIMENTS BEHAVIOUR

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Nowadays, it is common to talk about blue growth, blue biotechnology, ocean energy, seabed mining, aquaculture and coastal tourism. This intense use of the sea is reaching such a level of impact that governmental institutions are investing in regulations. The European Union issued the Marine Strategy Framework Directive to ensure a Good Environmental Status (GES) of European waters as well as the Marine Spatial Planning (MSP) to regulate human activities in an efficient, safe and especially sustainable way. In all the cases, a characterization of the seafloor is currently a necessity. Added to that, the complexity of the technology applied at sea for monitoring, construction or extraction of resources asks for a thoroughly understanding of the seafloor complexity. In order to improve the knowledge on this matter, our intention is to present different case studies on shelf areas where shell and shell fragments acts as modifiers of geotechnical properties and on acoustical response of silico-clastic sediments. Shells and shell debris are an important component of the seafloor, though in the past decades they were investigated in a limited way being on a grey zone between geology and biology and mostly presenting high level of complexity.

Evidence on the role of shells and shell fragments in modifying the acoustic measures by remote sensing were observed in the last decades by several authors. Particularly, Ivakin (2009) identified shells as responsible of the scattering above 200 kHz, Lyons (2005) focused on shall hash contribution to volume scattering mechanisms and Stanton (2000) investigated the scattering by partially buried shells. Added to real remote sensing measurements, we would like to illustrate how the carbonate content into the sediments can be a good indicator of backscatter variability.

Furthermore, considering the geotechnical behaviour of silico-clastic sediments, we would like to discuss how shell debris contributes on coarsening the sediment fraction and evaluate possible consequences. As last, we would like to steer the attention on how the plate and elongated structure of the shell fragments can potentially disturb the level of penetration into the substratum.

ONE NETWORK MAY HIDE OTHERS – TOWARD A COMPREHENSIVE SCENARIO FOR NEOGENE SUPERIMPOSED VALLEY NETWORKS ALONG THE ENGLISH CHANNEL

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The English Channel has been an area of intense geological investigation for decades, spanning various subjects such as structural and basin evolution between variscan and alpine orogenic cycles or sediment transport over a wide platform under tidal and storm currents. Among these subjects, one specific feature of the English Channel is the occurrence of a complex network of channels with clear morphological expression at the seabed. Since the beginning of the 20th century, and more pragmatically since the 1970s and the development of high-resolution seismic acquisition, this network has been the focus of several studies that proposed various scenarii for its origin and age. The existence of two superimposed networks had already been proposed in the late 70's. In 2015, in the framework of the geological mapping of the French continental shelf, BRGM acquired a dense grid of very high resolution marine seismic (MERCAUX 2015 cruise). Interpretation of these (i) confirms that several networks are superimposed, and (ii) details the real complexity and discontinuity of the older network(s) associated to the "*Fosses de la Manche*" system. Finally, thanks to high quality oil exploration seismic data (courtesy of HIS), we were able to reveal a local unexpected increase of bedrock incision and associated sedimentary fill up to c. 350 m. These observations and subsequent implications for networks origin and development are discussed with respect to regional geological settings and controlling parameters. Their significance in terms of source-to-Sink features is a key aspect as the English Channel is certainly an important zone of sediment transfer during Neogene, collecting from a large catchment and delivering to the Western Approaches, the Celtic Sea and the Bay of Biscay abyssal plains. Drilling selected targets to provide groundtruthing sounds now like the obvious next step.

REACTIVATION AND INTERACTIONS OF CADOMIAN AND VARISCAN INHERITED STRUCTURES WITHIN THE INTRACRATONIC ANGLO-PARISIAN BASIN REVEALED BY OFFSHORE STUDIES: THE FÉCAMP-LILLEBONNE AND NORD-BAIE-DE-SEINE FAULTS

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The Anglo-Parisian Basin is an intracratonic basin that covers a large part of Western Europe during Mesozoic and Cenozoic. In addition to widespread low amplitude thin-skinned structures, sedimentary series are affected by deep-seated structures that are reactivated throughout the evolution of the basin as the lithosphere accommodate various regional tectonic stresses related to plate tectonics. These structures expressed as faults and folds that traverse the entire basin and their pattern is modelled on boundaries and structures of cadomian and variscan tectonic domains. Following periods dominated by extensional tectonics related to oceanic opening around Europe during Trias, Jurassic and lower Cretaceous, the Anglo-Parisian Basin undergoes periods of tectonic inversion along inherited structures and large-wavelenght deformations classically associated with Africa-Europe convergence and Pyrenean and Alpine collisions and also North Atlantic opening ridge-push and Iceland Plume emplacement. In this study, we propose to reveal the structural complexity of interacting inherited structures that affect meso-cenozoic series, thanks to offshore very high resolution and dense seismic datasets. Benefiting from both the c. 1 m vertical resolution of the sparker seismic and the ability to acquire profiles wherever wanted, we have been able to detail the connection between the NNWSSE Fécamp-Lillebonne fault and the E-W Nord-Baie-de-Seine fault. It forms a succession of en-échelon folds and faults that confirm a local dextral transpressive component. The presence of NE-SW orientated structures is discussed as a possible feature linked to transpressive tectonics and/or as the result of reactivation of “cadomian” structures.

NUMERICAL MODELLING OF SEDIMENT GENERATION: A MODULAR APPROACH

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In this newly started research project we break down sediment generation into different modules so as to set up a numerical model. Since there is still an incomplete understanding of the evolution of grain size distribution and petrographic composition as a function of size during mechanical and chemical weathering, there is need for a model that will permit sedimentary provenance analysis to be carried out in predictive mode. Such a model is best developed in a modular way to ensure portability and maximization of future potential. Analysis and modelling of sediment generation require a unified approach to characterization of sediment properties across the full spectrum of grain sizes, along with an assessment of the solute fraction, so as to ensure mass balance. Bits and pieces of the knowledge needed for this are scattered across a range of disciplines in Earth sciences and engineering. Development of a sediment generation model is an attempt to put the pieces of this puzzle together.

The sediment generation model (SedGen) to be developed will be calibrated and tested with data from granitoid parent rocks and their weathering products. Legacy data are available from the work of Vistelius and co-workers, Ibbeken & Schleyer, and Heins, as well as from other research groups currently active in this field (ongoing work by Caracciolo, Critelli, Garzanti, von Eynatten, their coworkers and other research groups).

SedGen will consist of various modules starting with a constants module containing e.g. mechanical and chemical properties of rocks and minerals, and a preprocessing module to prepare data for input. Next are unit conversion, calculation and mass balance modules which will respectively perform i) e.g. the log-ratio transformations needed to successfully analyze the compositional data with standard statistical methods, ii) the simulation of mechanical weathering (inter-crystal breakage and intra-crystal breakage) and chemical weathering (dissolution of primary minerals, precipitation of secondary minerals, and accumulation of solutes), and iii) the bookkeeping of grain-and crystal size distributions within a Lagrangian framework, in which one can maintain full mass balance among weathering products. Finally an output (post-processing) module will visualize and/or tabulate the results in the form of ternary diagrams, grain size distributions etc. The application will be mainly written in Python for ease of use and graphical user interface purposes while Fortran will be used to ensure fast computation where needed.

The potential and innovation of SedGen lies in multiple aspects: 1) It will serve as a means to close the gap for source-to-Sink models, thus providing a significant increase in our understanding of Earth-surface dynamics. It can also provide new insights into the responses of our planet to (anthropogenic) environmental perturbations. 2) It will allow us to model the evolution of the composition and grain size distribution of weathering products, something which is poorly understood at present. 3) It can aid in reservoir characterization for CO_2 storage, geothermal applications, and hydrocarbon exploration and exploitation.

A PRELIMINARY STUDY ON THE OCCURRENCES OF VERTEBRATE FOOTPRINTS RELATED WITH PALEOENVIRONMENTS IN THE CRETACEOUS FLOODPLAIN AND LAKE MARGIN DEPOSITS, GYEONGSAN CITY, SOUTH KOREA

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Various footprints of dinosaurs and birds occur in the Cretaceous floodplain and lake margin deposits, Wachonri, Gyeongsan city, South Korea. These deposits consist of floodplain deposits (reddish or greenish gray interbedded to interlaminated fine-grained sandstone to siltstone and mudstone), lake margin deposits (gray interbedded to interlaminated fine-grained sandstone to siltstone and mudstone with mudcracks, shaly mudstone, planar-to cross-laminated fine-grained sandstone, tuffaceous sandstone, and stromatolites), and sublacustrine deposits (calcareous silty mudstone and gray interbedded to interlaminated fine-grained sandstone to siltstone and mudstone without mudcracks). Sulphate evaporite mineral casts are in places present in floodplain and lake margin deposits, and pedogenic laminar and nodular carbonates are occasionally present in lake margin deposits. Whereas floodplain deposits are prevailing in the lower part, sublacustrine and lake margin deposits are dominant in the upper part, indicating that lake expanded with time. The lower part deposits are usually reddish and greenish gray, whereas the upper part is gray to dark gray, also suggesting an invasion of reducing environment with time.

Whereas invertebrate body fossils and plant fossils are very rare in these deposits, vertebrate footprints and invertebrate trace fossils are occasionally observed. The Dinosaur footprints occur mostly in the reddish floodplain deposits of the lower part. Sauropod footprints are dominant, and some of ornithopod and theropod footprints are observed. Polygonal mudcracks are common and small-scale wave ripples are in places associated in the dinosaur track deposits. In the dinosaur track deposits, bird footprints are rarely associated and invertebrate traces of *Skolithos*, *Scoyenia*, and *Diplichnites* are in places observed. The bird footprints mostly occur in the reddish or greenish floodplain deposits of the lower part. They are mostly non-webbed and some of them are webbed. Some of non-webbed bird footprints are also present in the gray mudstone films on planar-to cross-laminated fine-grained sandstone oft he upper part. Invertebrate trace fossils are rarely observed in the bird footprint deposits.

In summary the ichnofacies of examined deposits can be assigned to the *Scoyenia* ichnofacies on eulittoral to supralittoral environment in low-energy depositional system of balanced-fill lake type to underfilled lake type basin, on the basis of lithofacies composition, presence of stromatolites and evaporite casts, and very rare occurrences of invertebrate body fossils and plant fossils.

CONTAMINATION RECORDS OF SEDIMENTS BY HEAVY METALS IN A MINING-IMPACTED DAM

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Dams represent favorable contexts for sediments to accumulate in large volumes. However, very little attention was paid to these environments until little more than a decade ago. These depositional environments influenced by anthropogenic activities may offer a large space of accommodation and are characterized by high rates of sedimentation (typically several cm.y^{-1} up to 200 cm.y^{-1} for some Asian streams). Metallic elements (ME) of natural or anthropogenic origin are one of the major sources of contamination within the sedimentary reservoir and represent a great environmental issue. Thus these sedimentary reservoirs may constitute sinks for the contaminants. Dam context allow studying the temporal evolution of contaminated sediments transfers (and ME) by different mechanisms (punctual or event). Moreover, natural phenomena (floods, drawdown, erosion, etc) and hydroelectric reservoir operations (normal, peculiar or punctual) may impact the historical sedimentary stocks and the associated contaminants, notably by the resuspension and homogenization processes. In that way, few studies have been carried out on the modification of the environmental compartment in hydroelectric dam contexts.

This study has been focus on a watershed affected by past mining activities (± 6 t of Ag and ± 6000t of Pb were extracted until the 19th century), where sediments have been accumulated for c.a. 1 century in a hydroelectric dam reservoir located downstream. A multi-scale approach (spatial and temporal) was promoted to study the sediments deposits in this affected context by ME (e.g., As, Pb, Cd, Zn). The sedimentary dynamic at the dam scale was detailed by sedimentological, geochemical and mineralogical analysis. The characterization of the sediments has been realized from top sediments (Ponar or Ekman grabs) through sedimentary archives since dam's creation (4 cores of 9 m max.), collected in the reservoir of interest. A sedimentological and geochemical study (Core XRF, spectrocolorimetry, XRD, SEM, Raman...) was carried out on sediments, characterizing the spatial (lateral and vertical) distribution of the ME within the reservoir. Sediment cores were collected in order to evaluate jointly the stratigraphic and geochemical evolution of the contamination in ME with time in the reservoir.

Some of the aims of this study are (i) to estimate the origin and contribution in ME between natural and anthropogenic sources, (ii) to determine the distribution of the ME within the sediments, (iii) to identify the various forms of the ME (mineralogy and speciation) in order to estimate their potential mobility and/or the parameters that would led to their remobilization. It should thus highlight if the reservoir sediments also act as a source of contamination. Determining the contamination chronicles at a reservoir scale is of primary importance for a sustainable management of the reservoir.

CYCLOSTRATIGRAPHIC CALIBRATION OF THE LATE DEVONIAN TIME SCALE

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The Late Devonian was affected by major, irreversible changes including two of the most severe biodiversity crises in Earth's history, the so-called Kellwasser and Hangenberg Events (respectively near the Frasnian – Famennian and the Famennian – Carboniferous boundaries). Currently, hypotheses for the Late Devonian extinctions include sea-level fluctuations and regression, climate cooling, ocean anoxia, massive volcanism and/or bolide impact. Unfortunately, testing these hypotheses is impaired by a lack of sufficient temporal resolution in paleobiological, tectonic and proxy climate records. Recent advances in astronomical calibration have improved the accuracy of the Frasnian time scale and part of the Famennian. However, the time duration of the Famennian stage remains poorly constrained even though this is the key to understanding cause-and-effect relationships of the Late Devonian greenhouse–icehouse transition marked by the onset of the end Famennian glaciation that ultimately led to the Hangenberg Event just prior the Devonian–Carboniferous boundary.

During the Late Devonian, an epieric sea in North-America mid-continent occupied the Illinois Basin where a complete Late Frasnian – Early Carboniferous succession of deep-shelf deposits was deposited. A record of this sequence, composed of calcareous shales, organic-rich shale, silty-shales and subtidal platform carbonates, is captured in three overlapping cores stored in the Iowa Geological Survey (H-30, Sullivan Slough and H-32). The H-30 core section spans the Frasnian-Famennian boundary; the Sullivan Slough section spans almost all of the Famennian (from Palmatolepis delicatula platys to lower part of the *Bithspadodus ultimus* zones of Spalletta et al., (2017) and the H-32 section sampled spans the upper part of the Bispathodus costatus through the *Protognathodus kockeli* Zone. The Devonian-Carboniferous Boundary, as revised by Spalletta et al. (2017) is at the base of the *P. kockeli* Zone.

To have the best chance of capturing Milankovitch cycles (long-and short-eccentricity cycles as well as obliquity and precession), 2200 rock samples were collected at 5-cm-interval across the entire sequence. Magnetic susceptibility (MS) was measured on each sample and the preservation of paleoenvironmental/climatic information into the signal was verified through geochemical analyses (Ti, Al, Zr by XRF) and magnetic measurements (low temperature magnetic susceptibility and IRM acquisitions). Correlation and overlap between each core was made using available conodont biostratigraphy and then refined by comparing the trends in the MS and $\delta^{13}C$ signals for critical intervals. To estimate the duration of the Famennian stage, we applied multiple techniques on the MS signal (multitaper method, evolutive harmonic analysis and adaptiveweighted harmonic F-test). By combining these techniques, we identified highly stable 405-kyr cycles across the Sullivan Slough and the H-32 cores. 405-kyr cycles were not observed in H-30, but 100-kyr cycles were identified. A preliminary estimate of the duration for the Famennian stage using the 405-kyr cycle as chronometer constrains the duration of the Famennian stage to 12.8 ± 0.4 Myr with an average sedimentation rate of 0.5 cm/kyr across the sequence.

MAGNETIC SUSCEPTIBILITY RECORDS FOR GLOBAL STRATIGRAPHIC CORRELATIONS? NEW CONSTRAINT IN THE CONTEXT OF CARBONATE PLATFORM RECONSTRUCTION (MIDDLE DEVONIAN, ARDENNES)

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This study undertakes a multi-disciplinary approach (sedimentology, magnetic susceptibility, geochemistry and hysteresis magnetic measurement) to increase our understanding of the Ardennes Givetian platform (Belgium and France) and to address a major question on the reliability of the magnetic susceptibility (MS) records for global correlations of marine carbonate records. Sedimentological analyses on two successions lasting millions of years, reveal an extended diversity of shallow-to off-reef palaeoenvironmental settings across the platform and allow to constrain the main sea-level fluctuations and associated environmental changes throughout the Givetian in Ardennes. The comparison of the two MS profiles allows to provide correlations, despite the long distance between the sections and their different sedimentological background. However, the comparison of the MS profiles from the Ardennes with contemporaneous data from the Rhenische Schiefergebirge (Germany) does not show any evidences of correlation, challenging studies that present the MS signal as a global correlation tool. These outcomes are crucial because they have repercussions on future global and regional stratigraphic issues as well as for paleoclimatic reconstructions. Here, we provide new evidences outlining that autogenic processes, which operate at long time scale, modulate the MS signal and have a strong influence over the magnetic susceptibility records that can leads to the absence of correlation within long-term MS trends.

LATE HOLOCENE MILLENIUM T-R CYCLES AND HUMAN IMPACT ON THE EVOLUTION OF A COASTAL BARRIER SYSTEM (W SARDINIA, ITALY)

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Climate changes are one of the main actual topics, and to define how much the human impact has and is affecting them is of outmost importance. Investigating how the climate has changed in the recent past is one of the keys to hypothesize possible future scenarios in the short/medium term.

In this respect, the Holocene has experienced short term, millennium scale T-R cycles having influenced (and will influence) the use of coastal plains by humans. The coastal areas are in fact the most sensitive to climate changes and those in which small eustatic and/or anthropogenic changes can cause significant environmental modifications.

Integrated archaeological and geological studies conducted on Mistras coastal barrier system (central Sardiniacentral Mediterranean, Italy), showed that it developed as transgressive systems during the final stages of the Holocene sea level rise (final stage of the Holocene Climate Optimum, about 6300-6000 years BP), and become regressive (prograding) from about 2500 years BP, when sea level reached the present elevation. The regression of the coast was, however, not continuous, but characterized by distinct Transgressive-Regressive cycles (T-R), associated to precise climatic fluctuations, tied with global eustatic and climatic phases.

The first T-R cycle occurred between 2800 and 2000 years BP. This time interval, known as Roman Warm, coincides with the Phoenician, Punic and Romans attendance of the west Sardinia coast. At that time, areas close to the coastal cities had to host landings and perhaps ports probably located at short distance from the shoreline. Archaeological excavations and findings have documented that in the Mistras area Punic constructed a long boulder structure (probably dated from the 4th Century BC) to better protect an incipient lagoon used as the harbour of the city of Tharros. This had the effect to modify the normal behaviour of the beach system that transformed from spit to barrier lagoon.

During the second T-R cycle, a well-established beach lagoon system developed quasi continuously for more than 1200 years (650 and 1850 AD). Beach regression started during a new warm period (Medieval) and continued favoured by gentle sea level fall occurred during the cold Little Ice Age time (1250-1850 AD). During this time, after the abandonment of the city of Tharros and of the Sinis Peninsula, the Mistras area was poorly populated. As consequence, there was no more an active harbour and large sandy dunes developed and nourished the shore allowing a no man-influenced progradation of the coast.

The third T-R cycle is the current one and begun about 167 years ago (post 1850 AD) after the relative sea level rise occurred after the end of the Little Ice Age.

Geological and archaeological data of a western Sardinia barrier lagoon system (Mistras) revealed that its evolution was human influenced since the Punic time. The study pointed that little human activities on the coast could influence its natural behaviour and landscape, and that little climatic changes both positive and negative can induce progradation or erosion of the system as well.

NEOGENE ARCHITECTURE OF THE FAIRWAY BASIN (NEW CALEDONIA, SW PACIFIC): DEEP WATER SEDIMENTARY PROCESSES, FLUID ESCAPE FEATURES AND POTENTIAL TRIGGERING MECHANISMS OF SUBMARINE LANDSLIDES

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The Fairway Basin (FB) is located offshore New Caledonia, in the South West Pacific. In the Neogene, this basin is considered as being tectonically inactive. Although very limited well controls are available, its overall structure, seismic stratigraphy and architecture are relatively well known. However, little is known on the detailed sedimentary processes controlling its recent infill. The originality of this basin lies in its atypical physiography, being perched between the Lord Howe Rise (LHR) and the New Caledonia Basin, its remoteness from any major terrestrial sediment sources during the Neogene, and the low slope values (< 1.5°) of its margins. Along with hemipelagic background sedimentation, various processes are involved in the Neogene architecture of the basin, such as turbidite flows, intraslope failures and post-depositional deformations. These processes are evidenced by both surface and subsurface features, such as typical submarine canyons, channels and lobes, slope failure headscarps and associated mass transport deposits (MTDs), sediment waves, pockmarks and polygonal faults. We propose that the Neogene infill is impacted by two main gravity systems (axial turbidites and lateral slope failures) which are thought to be active simultaneously since the Middle Miocene. The turbidite system is mostly developed in the northern part of the FB, where remobilised sediments are sourced from the presently almost completely drowned carbonate reefs of the Lansdowne Bank (LB) area. Along with this relatively restricted carbonate turbidite system (around 400 km long), two main mass failure complexes (25 % of the basin surface) originating from the basin lateral slopes affect the upper unit of Neogene interval of the FB. MTDs of the Northern Complex are derived from the LB slopes to the North or from the Fairway Ridge to the East. MTDs of the Southern Complex originate from the LHR slope, as evidenced by composite headscarp areas on the present day seafloor. The potential triggering mechanisms of MTDs are discussed in the context of this tectonically inactive margin. (1) MTDs of the Northern Complex could be directly attributed to the high slope values of the LB area (> 1.5°), yet a genetic link with downslope turbidity currents originating from the platform edge cannot be ruled out. (2) For the Southern Complex, surface slope values are lower (< 1.4°) and, at the exception of sandwaves of contentious origin, limited slope morphologies suggesting active downslope flow processes are seen. The role of fluid migration is thus suggested, notably since the FB shows several evidences for fluid generation (eg. polygonal faulting, pockmarks, presence of a widespread diagenetically-related BSR) and fluid overpressures. In addition, lithological/diagenetic boundaries within Neogene Unit (ie. vertical transition from indurated chalk to unconsolidated ooze) could be invoked as a key factor in the triggering of instabilities.

SHELF-MARGIN ARCHITECTURE AND SHORELINE PROCESSES AT THE SHELF-EDGE WITH CONTROLS ON SEDIMENT PARTITIONING AND DEEP-WATER DEPOSITION STYLE: INSIGHTS FROM 3D QUANTITATIVE SEISMIC STRATIGRAPHY

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The Lower Barrow Group (LBG; Latest Tithonian – Early Valanginian) is a shelf-margin that prograded during a late phase of rifting under various subsidence regimes and supply-dominated conditions. A 3D semi-automatic, full-volume seismic interpretation method allows identifying high-order clinothems presenting an estimated cyclicity of ~40,000 yrs, in which a quantitative analysis of the shelf-margin architecture and shorelines processes was conducted. Overall, three and four main types of hydrodynamic regimes and deep-water systems were identified, respectively.

Falling to flat shelf-edge trajectories are associated with sediment by pass, whereas rising shelf-edge trajectories are linked with increasing sediment storage on the shelf. While fluvial to wave processes can be dominant in all A/S conditions, results show that fluvial-dominated coastlines are associated with steep high-angle slope clinoforms and short to longer run-out turbidites. Conversely, wave-dominated coastlines are linked to low-angle slope clinoforms and poor turbidite system development (occasional sheet sand and MTDs).

The short and longer run-out turbidite systems present a tripartite architecture (canyon / slope valley; channel; lobes) which mostly appear as short-lived, vertically / laterally stacked elements fed my multiple small rivers forming linear ramp systems. Localized fluvial input promote retrogressive canyon development and direct fluvial-canyon connection which can promote the development of longer-lived fans and thicker turbidite accumulation compared to short run-out turbidite systems. Due to the shallow configuration of the margin (< 500 m), the presence of short slopes and overall high sand-to-mud ratio, the turbidite systems are smaller scale (< 50 km) and probably shorter lived than most modern turbidite systems (100-1000 km).

This study sheds new lights on the significant role of shelf-margin architecture (slope gradient, hydrodynamic regime) in predicting the deep-water sediment delivery behavior (sediment partitioning, type of deep-water system). This analysis unveiled the high resolution changes in sediment supply and accommodation in time and space in the LBG, and provided new insights on the distribution of shallow and deep marine plays in the basin. This innovative workflow constitutes a new step in sequence stratigraphy as it allows interpreters to map sequences in a true 3D environment hence taking into account the full variability of depositional systems in time and space.

CONTROLS ON SHELF-MARGIN ARCHITECTURE AND SEDIMENT PARTITIONING DURING A SYN-RIFT TO POST-RIFT TRANSITION: INSIGHTS FROM THE BARROW GROUP (NORTHERN CARNARVON BASIN, NORTH WEST SHELF, AUSTRALIA)

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The Barrow Group was deposited in the Northern Carnarvon Basin from the latest Tithonian to the Late Valanginian. This moderately deep-water shelf-margin is composed of ~100-500 m high clinoforms that prograded during a syn-rift to post-rift transition.

Integration of well data with extensive 2D and 3D seismic data was used to constrain the stratigraphic evolution of the Barrow Group in seven 3rd order seismic sequences (calibrated to dinocyst zones) across four main depocentres. Five shelf-margin categories were recognized based on stratal stacking patterns, the trajectory styles and angles (Tse), and the progradation/aggradation ratios (Pse/Ase) that were interpreted in terms of rates of accommodation creation and sediment supply (A/S ratio).

Following the uplift of the Southern Carnarvon Basin (sediment source), the stratigraphic evolution of the Barrow Group developed in three stages. During the first stage (late syn-rift I; 147-143 Ma), the shelfmargin prograded in a period of tectonic quiescence with relatively limited subsidence. During the second stage (late syn-rift II; 143-138 Ma), the shelf-margin was affected by increasing rates of accommodation and high sediment supply, which reflects an active period of rifting triggering both tectonic subsidence in the basin, and active uplift in the hinterland. During the third stage (early post-rift I; 138-134.9 Ma), the uplift of the continental shelf, following continental break-up, provided a new, local source of sediment supply to shelf-edge then developed as a passive margin.

The Lower Barrow Group (late syn-rift I and II) mainly developed under supply-dominated conditions. However, lateral variations in subsidence regime and shifts in sediment supply led to significant variations in shelf-margin architecture along-strike, directly impacting the sediment-budget partitioning between the shelf and the deep-water areas. Flat shelf-edge trajectories were associated with sediment by pass and increase in bottomset thicknesses, whereas rising shelf-edge trajectories were linked with sediment storage on the shelf. In contrast, the Upper Barrow Group (early post-rift I) developed in low-supply conditions with slow thermal subsidence, reflecting the passive context of the margin at this time.

The Barrow Group provides a unique example of how rift tectonics can control the stratigraphic architecture of a regressive margin and reciprocally, how studying shelf-margin architecture can help constraining the dynamics and timing of rifting around the break-up stage.

EVOLUTION OF LATE OLIGOCENE – EARLY MIOCENE ATTACHED AND ISOLATED CARBONATE PLATFORMS IN A VOLCANIC RIDGE CONTEXT (MALDIVES TYPE), YADANA FIELD, OFFSHORE MYANMAR

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This study investigates the stratigraphic evolution of the Late OligoceneEarly Miocene carbonate platforms of the Yadana area (offshore Myanmar). Well data, regional 2D and local 3D seismic surveys allow the identification of three shallow-water carbonate platforms (Yadana, 3DF and 3DE) showing various morphologic and stratigraphic patterns influenced by the presence of a paleohigh. The identification of seven seismic sequences in the Yadana area constrains the stratigraphic evolution in three stages: (1) development of aggrading attached and isolated platforms during the Chattian; (2) a period of platform emersion during the OligoceneMiocene transition; (3) drowning of the smaller buildup (3DE) associated with km-scale backstepping on the large platforms (3DF and Yadana) during the Aquitanian. The Aquitanian marks the onset of renewed volcanic activity associated with the development of fringing carbonate reefs during the Burdigalian.

The rapid (~6 My) development of these wide (~5-70 km) and thick (~300-850 m) carbonate platforms has been mainly controlled by the subsidence. However, the results highlight a strong overprint of eustatic fluctuations on the rates of change in accommodation, and hence on the stratigraphic architecture of the carbonate platforms.

Based on an alternative model for the Cenozoic geodynamic evolution of the Yadana area, our results suggest that the platforms developed on a volcanic ridge of hotspot origin located in the Indian Ocean and not on a volcanic arc. Subduction jump processes are interpreted to have played a key role in the demise of all platforms by drastically changing the paleoenvironmental conditions during the Early Miocene, and led to the present-day location of the Yadana Ridge in a back-arc setting.

The carbonate platforms from the Yadana area are thus a representative example of the interplay between global mechanisms and local paleoenvironmental parameters on carbonate platform initiation, growth and demise.

CARBONATE DIAGENESIS – AN EXPERIMENTAL MULTI-PROXY APPROACH

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Carbonate sediments (and rocks) and biominerals are important archives of environmental conditions in the geologic record, and are widely used as proxies for both depositional and paleoenvironmental reconstructions, providing insight to ambient temperature, salinity, alkalinity, oxygen conditions, and water sources. The alteration process and diagenetic products of carbonate minerals are therefore important to understand if one is to use them for the reconstruction of these paleoenvironments. This study uses an experimental approach, where various aragonitic carbonates are subjected to known diagenetic conditions including pore water chemistry (meteoric and brine fluids), and temperature (unaltered, 100, 130, 160, and 200°C), and analyzed for petrographic and geochemical alteration. By comparing unaltered and hydrothermally altered subsamples from one specimen, heterogeneity is reduced, and a directly comparison of textural and geochemical changes of the specimen can be made. By utilizing both conventional and novel analytic techniques (e.g., clumped isotope analysis), the comparison of specimens from these varying burial conditions allows a quantitative and systematic approach to determine the type and extent of diagenesis in the experimentally altered samples.

Intermediate temperature ranges (130-175°C) show promise for the evaluation of both diagenetic mechanisms, as well as rate limiting factors during alteration. Initial results indicate partial recrystallization of different types of biogenic carbonates (corals, bivalves, gastropods, ammonites, and speleothems) from the 160°C experiments, with a visually distinct recrystallization front for some specimens. Results show the diagenetic pathway preferentially following micro-fractures and internal structures within the organo-sediments and laminae, possibly produced during initial formation. These pathways also indicate preferential movement of intercrystalline (water soluble) organics in samples such as bivalves, as they appear to be pushed away from the diagenetic front, causing concentration of the water insoluble organics, and the production of visually darker areas around fractures.

In addition to petrographic analyses, geochemical comparisons are made using light stable isotopes ($\delta^{13}C$ and $\delta^{18}O$), carbonate clumped isotopes, and elemental analysis, providing additional information on the transformation process from pristine Aragonite to secondary carbonate minerals. When comparing the unaltered to experimental diagenetic samples, a clear trend is seen in the replacement of Sr^{2+} ions with Mg^{2+}, Ca^{2+}, and other divalent ions, as the carbonate sediments (particularly apparent in the corals and bivalves) move from the less stable aragonitic structure, to more stable carbonate minerals such as low-Mg calcite. These initial results have implications for the stabilization and diagenetic progression of biogenic carbonates in the geologic record, and can be used to systematically track the alteration process using known diagenetic regimes.

4D STRATIGRAPHIC MODELING OF A TERTIARY CARBONATE SYSTEM

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Characterizing an entire field after a couple of appraisal wells is still a challenging effort, especially in carbonate environments. To do so, 4D forward stratigraphic modeling can be an efficient tool bridging between the relatively coarse seismic resolution and the very high resolution that wireline logs, or detailed core analysis can provide.

The challenge of our study was thus to achieve fast and accurate stratigraphic numerical models of a carbonate reservoir (average thickness about 250 m) integrated with all the available data, from seismic, wellbore logs and sedimentology, at an appraisal scale (2000 km^2, using a grid point spacing about 250 to 500 m). Modelling the dynamics of sedimentary systems using 4D Forward Stratigraphic Modeling and simulating the filling of sedimentary basins allowed bridging the gap between geological conceptual model and geostatistical simulation.

First part of the preliminary necessary work prior to build the model was to review the available data, to propose an adequate depositional model (Figure 1). In this particular case, detailed seismic interpretation has been carried out, as well as precise key morphologic structures identification, to define the macro scale stacking of sedimentary bodies and sequences.

An extensive review of the well scale information has also been performed including:

- Core logs, including sample descriptions, poro-perm values, paleosetting interpretation
- Core photographs
- Microphotographs of all thin sections taken from conventional cores and SWC samples
- Thin sections from cuttings and SWC
- Striplogs (lithologic logs)

All the gathered information's were thus integrated into a conceptual depositional model.

Once the task of defining the conceptual model done, the second phase of modelling could start. In our study, the model was performed over an 11 My time interval and a more than 2000 km^2 area, using a regular Cartesian grid with a 250 m point spacing. At each time step (i.e. every 50 ky), three main stratigraphic processes are simulated:

- the basin deformation induced either by subsidence or eustatic sea-level variations;
- the sediment supply, and in particular the carbonate production; and
- the transport of sediment towards the accommodation space created by the basin deformation.

The simulated total sediment thickness of the Reservoir, but also the simulated facies distribution observed along each well, were measured and compared to seismic, sequence analysis and wellbore data. This quality control allowed us to tune progressively each parameter until a best-fit was reach. The Reservoir (up to 350 m) was modelled in a set of 3 main eustatic sequences. Top and Base Carbonate reservoir were defined by maps derived from seismic interpretation.

This complex integrated study of a Tertiary Carbonate reservoir successfully shows that a consistent model with fine-tuned parameters is capable to reproduce all the main sedimentary process trough time to correctly reproduce the stratigraphic architecture. Thus, this modelling study successfully mimic the stacking of a partially rimmed shelf Carbonate Platform development and progradation.

COMPLETE PETROLEUM SYSTEMS ASSESSMENT AT PASSIVE MARGIN SCALE USING FORWARD STRATIGRAPHIC MODELING AND POSSIBLE ASSOCIATED SOURCE ROCKS CHARACTERIZATION

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Forward Stratigraphic Modeling is nowadays an efficient and useful tool to test various geological scenarios, and discriminate key sedimentary processes of transport during the infilling history of a basin. Still, building a coherent model consistent with different events and processes over a long geological time frame is not an easy task. In this case study, the challenge was to model a complete passive margin, reproducing the main observations at wells and the key features seen on seismic, in a single and reliable model of evolution of the margin over a hundred of millions years.

Furthermore, once the global conditions and the sedimentary dynamics of the evolution of this Passive Margin were defined by Forward Stratigraphic Modeling, a set of computation of Marine Organic Parameters was launched to address the main characteristics of the Source Rocks, improving the constrains on the Petroleum System.

In our study, the model was performed over a 110 My time interval and a more than 25,000 km^2 area, using a regular Cartesian grid with a 2 km point spacing. At each time step (i.e. every 250 ky), three main stratigraphic processes are simulated:

- the basin deformation induced either by subsidence or eustatic sea-level variations;
- the sediment supply, and in particular the carbonate production; and
- the transport of sediment towards the accommodation space created by the basin deformation.

The simulated total sediment thickness of the Passive Margin, but also the simulated facies distribution observed along each well, were measured and compared to seismic, sequence analysis and wellbore data. This quality control allowed us to tune progressively each parameter until a best-fit was reach. Once this global sedimentary framework was set, and calibrated honouring Seismic thickness and morphological features, but also coherent with well data and sediment proportion, a Marine Organic Matter study associated to the sedimentary context was carried on.

In this Marine Organic Matter computation several parameters such as Primary Production laws function of nutrient supply, degradation laws along the sea water column and early burial, redox conditions based on basin physiography and organic matter production are estimated. This complex integrated study of a Passive Margin successfully shows that a consistent model with fine-tuned parameters is capable to reproduce all the main sedimentary process trough time to correctly reproduce the stratigraphic architecture. Thus, this modelling study successfully mimic the stacking of such different objects as Submarine mega canyon, pulses of turbidite flows and Attached Carbonate Platform development and progradation.

Furthermore, this kind of large scale integrated study brings notable and valuable information on the architecture of all the elements of the Petroleum System, from depositional conditions of Organic Rich layers to Reservoir size, continuity, connectivity, quality and EOD, and Seals thickness and efficiency. Finally the Marine Organic Matter simulation helped to identify and characterize possible relevant Source Rocks layers, and thus bring one more step of refinement to the description of this Petroleum System.

CONTRIBUTION OF A MULTI-SCALE STUDY FROM DEEP TO SURFACE PROCESS: EXAMPLES FROM THE EBRO PARADOX

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The connection of the endoreic Ebro Basin (NE Spain) to the Valencia Basin (VB) in the past is still a matter of debate: did it occured before or after the Messinian Salinity Crisis (MSC: 5.97 to 5.46 Ma), one of the most dramatic environmental event that deeply affected the Mediterranean area? Following various interpretation, different preserved morphological and fluvial stratigraphic features are expected onshore and offshore the study area. Accordingly, great attention has been devoted to the chronostratigraphic and palaeoenvironmental interpretation of sediments deposited just before and during the MSC. This problematic thus implied a multi-scale analysis encompassing geodynamics, basin segmentation, sedimentary infill and Neogene subsidence.

Detailed analysis of seismic profiles and boreholes in the VB reveals a differentiated basin, the Minorca Basin (MB), lying between the old Mesozoic Valencia Basin sensu strico (VBss) and the young Oligocene Liguro-Provençal Basin (LPB). The Central and North Balearic Fracture Zones (CFZ and NBFZ) that border the MB represent two morphological and geodynamical thresholds that created an accommodation in steps between the three domains. From a geodynamic viewpoint, the counterclockwise movement of the Corso-Sardinian blocks induced a counterclockwise movement of the Minorca block towards the SE along the CFZ and NBFZ, during the exhumation of lower continental crust in the LPB. No (if not weak) horizontal Neogene movement has been found for the Ibiza and Majorca islands and implies a vertical Neogene “sag” subsidence.

Associated with the Messinian event a complete 270 km long Messinian Ebro incised-valley system across the VBss from the Catalan foothills to the CFZ is highlighted. Its related U12c falling systems tracts and Lower Unit, Mobile Unit lowstand systems tracts are mainly observed in the MB while Upper Unit transgressive deposits recover and preserve the former Messinian incised-valley. Similarities between present-day catchment area and Messinian fluvial length between the Ebro and Rhone systems confirm an ante-MSC Ebro Basin opening to the Mediterranean Sea. As the CFZ area is associated to the Messinian palaeo-Ebro mouth, we propose an estimate of the main MSC sea-level fall amplitude based on the geometry of the seismic sedimentary markers. The existence of a pre-Messinian step-by-step deepening physiography and segmentation in the Valencia-Provençal Basin plays a crucial role on the subsidence history and paleo-depositional profile. The regressive erosion process and the development of the incised valley system during the MSC sea-level fall is controlled by a step-by-step deepening morphology. The knickpoints plays a key role in the fluvial process during the sea-level fall, developing respectively along the offshore VB and along the foothill of the Alps for the respective palaeo-Ebro and Rhone systems.

THE APENNINE FOREDEEP (ITALY): A PERCHED ISOLATED BASIN DURING THE MESSINIAN SALINITY CRISIS

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The Adriatic Basin (Central Mediterranean Sea) is the place of intense controversy concerning the sedimentary dynamics and palaeogeographic evolution during the Neogene, especially during the Messinian Salinity Crisis (MSC: 5.97 to 5.46 Ma). Following the various interpretations, this basin was totally disconnected or connected to the deep basins during the MSC. Accordingly, much attention has been devoted to the chronostratigraphic and palaeoenvironmental interpretation of the sediments deposited in the Apennine foredeep after the peak of the MSC.

We performed calcareous nannofossil and dinoflagellate cyst analyses on five sections along the Apennine foredeep (Monticino, Maccarone, Civitella del Tronto, Fonte dei Pulcini, Fonte la Casa). The studied interval belongs to the p-ev2 (post-evaporitic) Formation that includes the Colombacci deposits, emblematic of the Lago Mare in the area. Marine microfossils recorded in previous studies have often been neglected or considered reworked and hence discarded. We propose the occurrence of at least four marine inflows between 5.36 and 5.33 Ma, each of them being indicated by marine dinoflagellate cysts that are rapidly replaced by Paratethyan (brackish) ones. From this perspective, the Apennine foredeep is to be considered an isolated perched basin during most of the peak of the MSC (5.60–5.46 Ma), which was progressively and repeatedly invaded by marine waters overflowing a palaeo-sill before the beginning of the Zanclean (5.33 Ma) consistently with the global continuing eustatic rise. Additional multiscale approaches (seismic and well studies, field data) of the sedimentary filling were used to highlight the tectono-stratigraphic evolution around the Gargano Peninsula (i.e. the Pelagosa palaeo-sill). Analysis of the Tertiary sedimentary megasequences allows us to identify several depocenters along the Apennine Chain and South Adriatic Basin. These observations emphasize the crucial role of the Mesozoic carbonate platforms and basins and the Apennine Chain formation in the palaeogeographic evolution of the Adriatic domain. Messinian time likely was a crucial period for the uplifting Apulian-Gargano Dinaride composite threshold.

The Lago Mare cannot be considered as a uniform brackish palaeoenvironment but must be envisioned as a complex mosaic of sedimentary facies resulting from competing marine and brackish waters controlled by physiographic factors. The Mesozoic heritage with the Apennine front propagation plays a major role in the palaeo-environmental evolution of the Apennine foredeep. Deposits overlying the unconformity separating the regional p-ev1 and p-ev2 formations must henceforth be regarded as representing the first marine incursion into the isolated central Adriatic Basin after the peak of the MSC. These results allow us to refine the palaeogeographic reconstruction of the Apennine foredeep during the peak of the MSC. Although this basin was deep, its history during the peak of the MSC did not parallel that of the central Mediterranean basins.

A CYCLE OF SAND SPIT NOURISHMENT BY SWASH BARS ON MACROTIDAL EBB-TIDAL DELTA

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The focus of our study is the Orne river inlet located in the southern coast of the English Channel, Ouistreham in Normandy, France. This coast is a macrotidal coast which experiences 6.7 m of tidal range during mean spring tides. The mean significant wave height is 0.35 m with a mean water depth of 8.5 m and the wave periods are between 4 and 7 s. The net longshore sediment transport is eastward with local reverse transport observed along the down-drift side of the inlet. LiDAR airborne surveys provide seasonal topographic data of the entire inlet at low tide, from February 2011 to May 2017 (12 surveys). A wave and tide recorder measures tide and directional waves every hour since 2007. The major part of the nearshore zone is fine sands with grain size ranging between 125 to 250 µm. The swash bars over the ebb-tidal delta formed by medium to very coarse sands with also many broken shells. The aim of this study is to investigate the topographical and morphological responses of the ebb-tidal delta to the main hydrodynamic forcings. The exposed part of the ebb-tidal delta at low tide is close to 5 km^2 during high spring tides. The LiDAR data highlight an increasing of the sediment volume of the up-drift side of the delta and a decreasing of the sediment volume on the down-drift side. The extent of both sides (up and down-drift side) of the ebb-tidal delta has been decreasing since 2011. The relationships between the main spit and the swash bars over the ebb-tidal delta are also examined. These swash bars migrate towards the south, at a rate of 6-7 m/month during winter and 3-4 m/month during summer. This supply of sediment feeds an unusual “L” shaped spit. The 6 years LiDAR dataset shows a complete cycle from the swash bar migration to the spit hook formation.

DECIPHERING PALEOCLIMATE SIGNAL IN COMPLEX LAMINATED SPELEOTHEMS FROM HIGH-ALTITUDE CAVE (LA CIGALÈRE, PYRENEES)

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Past decade has seen the increasing use of karstic speleothems as natural efficient recorders of past environmental changes. Due to its potential link with high-frequency fluctuations and seasonality, speleothem lamination has attracted growing interest in environmental studies and may reveal a powerful tool in areas highly sensitive to climate variations such as mountainous regions. We report results from a complex laminated flowstone in a high-altitude cave in the Pyrenees. The main objectives of this research are: 1) to characterize the different types of laminae, 2) to document their scaling and geometrical relationships, and 3) to decipher the environmental parameters controlling formation of the various types of laminae and to explain their stacking patterns in terms of paleoclimatic signal.

The emblematic Cigalère Cave is world-renowned for the remarkable beauty and diversity of its speleothems. The cave is located at an altitude of 1700 metres on the northern side of the Pyrenees and is open into limestones and marbles of Ordovician age. Ore deposits occur in rock formations overlying the cave system and Pb-Zn mining were working until the middle of the 20th century.

The methodological approach involves careful assessment of the preservation of material regarding diagenesis and is based on a suite of mineralogical, geochemical and petrographical analyses: XRFEDS spectrometry on polished slabs, optical microscopy, Raman microspectrometry, UV fluorescence microscopy, secondary and backscattered SEM, X-ray EDS. U/Th dating of sub-samples provides the necessary framework for interpreting results in terms of climate changes.

Several minerals have been identified in the flowstone. These are carbonates [aragonite, calcite, smithsonite ($ZnCO_3$), hydrozincite ($Zn_5(CO_3)_2(OH)_6$), Zn-oxides and hydroxides, and a Zn-rich silicate. The main post-depositional diagenetic change is the partial recrystallization of aragonite layers into low-magnesian calcite. This process can emphasize or strongly alter the primary lamination, or even generate apparent lamination.

Four types of laminae occur: mineralogical lamination resulting from alternating layers of aragonite and calcite, geochemical lamination in calcite and in aragonite, luminescent lamination.

Alternating aragonite and calcite layers forms a first-order mineralogical lamination. Within this pattern, a second-order aragonite-calcite lamination is visible in some places.

Some aragonite layers show internal laminations of second and third orders. Primary calcite layers display luminescent laminae when excited with light of different wavelengths, forming a second-order luminescent lamination. SEM-EDS mapping of Ca and Zn distribution in primary calcite layers revealed a second-order geochemical lamination caused by variation of Zn content in calcite. The top of these calcite layers can be coated by Zn-rich minerals.

Sequential stacking pattern shows that each sequence begins with a layer of acicular aragonite, overlain by a Zn-Ca laminated calcite. The top of each sequence is marked by a discontinuous coating of Zn-rich minerals: Zn-oxides and hydroxides, and Zn-carbonates. Sometimes, these are in turn overlain by Zn-rich silicates. This sequential pattern clearly reflects variations in drip-water chemistry and drip rates, which are linked to changes of environmental parameters inside and outside the cave and also to the alteration of ore-deposits overlying the cave system, providing a potentially high-resolution record of paleoclimatic signal.

NATURAL CLIMATIC ARCHIVES IN THE ECTOPYR PROJECT: IMPACT OF PAST CLIMATIC FLUCTUATIONS ON THE DIVERSITY OF PYRENEAN TERRITORIES

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Mountain areas are particularly sensitive to abrupt climate changes and the Pyrenees are today increasingly affected by the current global warming. ECTOPYR is a project of cross-border cooperation between France, Spain and Andorra, scheduled in the Interreg V-A-POCTEFA programme (2014-2020) and mainly funded by the Regional European Fund (FEDER). The cooperative consortium includes partners in Spain (CRARC, Centre de Recuperacio d'Amfibis i Reptils de Catalunya), France (SETE, Station d'Ecologie Théorique et Expérimentale UMR5321; Nature Midi-Pyrénées), and Andorra (BOMOSA Venture Philantropy).

ECTOPYR is based on an interdisciplinary past-present-future approach and is using a panel of 8 ectotherm species (reptiles and salamanders) occurring from low-streams to high-altitude rock-fields, as bio-indicators of climate change in the Pyrenees. The main objectives of the project are: 1) to assess each bio-indicator's response to climate change, 2) to describe the natural variability of the Pyrenean climate over the Holocene and 3) to generate modelling tools in order to anticipate the effects of climatic change on each model organisms.

The project component concerning the natural climatic archives aims to decipher changes of Pyrenean climate during the Holocene from the analysis of speleothems. The methodological approach includes a calibration phase with environmental monitoring of selected sites in caves located on both sides of the mountain range, and the detailed study of potential diagenetic changes in each speleothem. More specifically, the effects of the altitudinal gradient and the potential environmental contrasts between the northern and southern sides of the Pyrenean range will be assessed by selecting material from foothill and high-altitude caves on both sides of the mountain range. Preliminary results obtained from cave monitoring and stalagmites of the northern side of the Pyrenees are presented.

CONTROL OF BASEMENT HETEROGENEITY ON THE SEDIMENTARY ARCHITECTURE IN LOW RATE SUBSIDENCE INTRACRATONIC PALAEOZOIC BASINS: EXAMPLE OF AHNET AND MOUYDIR BASINS

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The North Africa intracratonic Paleozoic platform is characterized by an association of arches (ridges, domes or paleohighs) and syncline-shaped basins of different large-scale wavelengths with low rate subsidence. The Ahnet and Mouydir basins which are part of the platform are bordered (from E to W) by the Amguid El Biod, Arak-Foum Belrem and Azzel Matti arches. They are chosen as an interesting case of study because of high quality satellites images combined to significant geological data base (e.g. well, seismic, field trips, geological report) surveyed during many years of petroleum exploration (since 1950s). This study is based on the compilation and integration of well-log, seismic, and satellites images data.

Several tectono-sedimentary structures such as wedges, truncatures, onlaps were identified and related to distinct tectonic events often associated to major unconformities: the Cambro-Ordovician extension, the Ordovician-Silurian glacial rebound, the Siluro-Devonian “Caledonian” extension/compression, the late Devonian extension/compression and the “Hercynian” compression. During the Cambro-Ordovician, the deformation is accommodated by characteristic sub-vertical planar normal faults (sometimes blind faults) forming horsts-grabens systems associated to forced folds (normal drag folds). These latter structures can be inverted (positive inversion) or reactivated (forced folds) during the Devonian and the Carboniferous. At the basin scale, thickness variation and facies portioning can be deciphered between arches and basin synclines. The arches are characterized by thin sedimentary successions, amalgamation, condensation and erosion of series. The depositional environments are generally more proximal and correspond to mixed carbonate-clastic platforms. In the basins synclines are featured by increase thickness of series and deeper environmental settings. These basins are defined by a differential low-rate subsidence (i.e ca. 10 Ma to 50 Ma), which is in turn rhythmed by periods of increase and decrease of the rate according to regional geodynamic events.

The arches are featured by complex sub-vertical faults systems inherited from Precambrian. These Precambrian heritages controls the faults nucleation of the further tectonic events. We show that the origin of these differences in sedimentary cover and in subsidence rates are to be linked to the basement heterogeneity, resulting from the accretion of Archean to Proterozoic terranes of different origin (e.g., continental core, island arc) and rheology during Precambrian orogens (e.g. Eburnean and Pan-Afican orogeny). We therefore point out the role of basement heterogeneity in controlling both architecture and structural framework of these basins.

UPPER TRIASSIC LIMESTONES FROM THE NORTH END OF JAPAN: NEW INSIGHTS ON THE PANTHALASSA OCEAN AND HOKKAIDO ISLAND

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In comparison with the well-known Tethyan domain, and despite of the amount of research already carried out, Upper Triassic limestones from the Panthalassa Ocean remain poorly known. However, these carbonates represent a unique opportunity to have a more accurate view of the Panthalassa during the Triassic. One of the best areas for the study of these carbonates is Hokkaido Island (north end of Japan), where many Triassic limestones outcrops are exposed. Furthermore, this island is a part of the South-North continuity of Jurassic to Paleogene accretionary complexes, going from the Philippines to Sakhalin Island (Far East Russia). The Jurassic and Cretaceous parts of these complexes, in Southern Japan and Philippines, are known to contain tropical Triassic mid-oceanic seamount carbonates from the western Panthalassa. For this reason, the aim of our research is to study in detail the Triassic limestones of Hokkaido and to then compare them with Triassic carbonates from other Asians accretionary complexes.

Two major tectonic units have been accurately explored and extensively sampled: the Jurassic Oshima Belt (west Hokkaido), and the Cretaceous Sorachi-Yezo Belt (central Hokkaido). Through a full sedimentological, diagenetic and biostratigraphic study, these limestones allow us (1) to compare the depostional settings and biotic assemblages from Tethyan and Panthalassic domains, (2) to better understand the geodynamic evolution of central part of Hokkaido Island and (3) to propose a model of evolution of these carbonates from their deposit to their accretion.

The preliminary microfacies analysis allowed us to recognise two new facies, never observed before in the Triassic limestones of Japan: (1) Stromatolitic/thrombolitic bindstone with fenestral fabric and (2) Bryozoans-Peloids-Echinoderms rudstone characterised by the lack of reef builders organisms. These two new facies are extremely important to highlight differences of depostional conditions between Triassic limestones from Southern Japan and those from Hokkaido. Indeed, the biological assemblage containing abundant Bryozoans might be a good marker of a cooler depostional environment than tropical reefs from southern part of Japan. Stromatolitic limestone, on the other hand, is typical of supratidal environment, not characteristic of mid-oceanic seamount carbonates.

The Sorachi-Yezo Belt is composed of Cretaceous accretionary complexes in the East and of Cretaceous clastic basin sediments deposited on a Jurassic basement in the West. This last part is also marked by a metamorphic zone containing Triassic limestones: the Kamuikotan Zone. The origin of Kamuikotan is still a matter of debate especially because it is not in continuity with any other complex known in the southern part of Japan and also due to the lack of data from this region. This metamorphic area is today considered as identical to the eastern part of Sorachi-Yezo Belt, a Cretaceous accretionary complex, but subducted and then exhumed during the Neogene. In-depht diagentic and geochemical analyses of Triassic limestones from both the Kamuikotan Zone and the other accretionary complexes in Hokkaido, will allow us to get new data to better comprehend the origin of Kamuikotan Zone.

EVAPORITIC MINIBASINS OF THE SIVAS BASIN (TURKEY)

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The Oligo-Miocene Sivas basin (Turkey) was strongly affected by salt tectonics, best expressed in its central part. Halokinesis initiated from a main evaporite layer deposited during the Upper Eocene. Such evaporitic accumulations led to two generations of mini basins filled with continental to marine deposits, and nowadays separated by diapiric gypsum walls or welds.

Some mini-basins developed above depleting diapirs, filled by more than 50 % of lacustrine to sebkhaic gypsiferous facies. These evaporitic mini-basins (EMB) developed during periods of limited fluvial input, when diapiric stems were outcropping with insignificant topographic reliefs. Chemical analyses (S, O and Sr) suggest that such evaporites were sourced from the recycling of adjacent salt structures.

EMB development above diapirs can be explained by (i) high regional accommodation, (ii) erosion of the diapiric crests by the fluvial system preceding evaporite deposition, (iii) deflation of some diapirs in a transtensive setting, and (iv) fast sedimentation rate of the evaporites. EMB stand out from other siliciclastic mini-basins of the Sivas Basin by (i) their small dimension (< 1km), (ii) their teardrop encased shape and (iii) exacerbated internal halokinetic deformations. The latter specifically include large halokinetic wedges, mega-slumps or inverted mega-flaps. Comparison with siliciclastic mini-basins suggests that strong halokinesis of EMB was triggered by the ductile rheology of their evaporitic infilling.

Additional filling and subsequent withdrawal of EMB may have been also increased by (i) the large amount of solutes provided by the leaching of the outcropping diapiric structures together with the fast sedimentation rate of the evaporites and (iii) the high density of gypsum and anhydrite compared to halite.

The Great Kavir in Iran could display present day analogues relevant of early-stage EMB. Finally, although EMB have never been identified in other ancient halokinetic settings, they may have developed in arid, continental environments such as in the Precaspian Basin.

TRANSITION FROM MARINE DEEP SLOPE DEPOSITS TO EVAPORITIC FACIES OF AN ISOLATED FORELAND BASIN: CASE STUDY OF THE SIVAS BASIN (TURKEY)

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The Sivas Basin, located in the central part of the Anatolian Plateau in Turkey, formed after the closure of the northern Neotethys from Paleocene to Pliocene times. It developed over an ophiolitic basement obducted from the north during the Late Cretaceous. During Paleocene to Eocene times, the onset of the Tauride compression led to the development of a foreland basin affected by northdirected thrusts. The associate general deepening of the basin favored the accumulation of a thick marine turbiditic succession in the foredeep area, followed by a fast shallowing of the basin and thick evaporitic sequence deposition during the late Eocene. We present here the detailed sedimentological architecture of this flysch to evaporite transition. In the northern part of the basin, volcanoclastic turbidites gradually evolved into basinal to prodelta deposits regularly fed by siliciclastic material during flood events. Locally (to the NE), thick-channelized sandstones are attributed to the progradation of delta front distributary channels. The basin became increasingly sediment-starved and evolved toward azoic carbonates and shaly facies, interlayered with organic-rich shales before the first evaporitic deposits.

In the southern part of the basin, in the central foredeep, the basinal turbidites become increasingly gypsum-rich and record a massive mega-slump enclosing olistoliths of gypsum and of ophiolitic rocks. Such reworked evaporites were fed by the gravitational collapsing of shallow water evaporites that had previously precipitated in silled piggy-back basins along the southern fold-and-thrust-belt of the Sivas Basin. The tectonic activity that led to the dismantlement of such evaporites probably also contributed to the closure of the basin from the marine domain.

From the north to the south, subsequent deposits consist in about 70 meters of secondary massive to fine-grained gypsiferous beds interpreted as recording high to low density gypsum turbidites. Such facies were probably fed from shallow water evaporitic platforms developing contemporaneously along the borders of the halite-and gypsum-saturated basin.

Finally, the reworked evaporites are sealed by a thick (> 100 m) chaotic and coarse crystalline gypsum mass, carrying folded rafts and boudins of carbonate and gypsum beds. Such unit is interpreted as a gypsiferous caprock resulting from the leaching of significant amount of halite deposits. Gypsum crystals are secondary and grew from the hydration of anhydrite grains left as a residual phase after the leaching of halite. The halite probably formed in a perennial shallow hypersaline basin fed in solute by marine seepages. This former halite sequence is interpreted to have triggered mini-basin salt tectonics during the Oligo-Miocene.

The described facies and proposed scenario of the Tuzhisar Formation in the central part of the Sivas Basin may find analogies with other Central Anatolian Basins (e.g. the Ulukisla Basin) or with other basinwide salt accumulations in the world (e.g. in the Carpathian Foredeep).

PALAEOEARTHQUAKE TRACES IN PLEISTOCENE LACUSTRINE SEDIMENTS (BALTIC SEA BASIN)

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Fluctuations in the extent of the successive Pleistocene ice sheets had consequences for the occurrence of earthquakes, and thus also for natural hazards. The thick ice caps caused a high cryostatic pressure on the mineral substratum, resulting in crustal subsidence during rapid ice accretion and in uplift during melting. Geologically extremely rapid changes in altitude by glacial rebound of the Earth crust after retreat of the Scandinavian Ice Sheet at the end of the glaciations influenced the palaeogeography of northern and central Europe. Isostatic rebound led to earthquakes and, if the conditions were suitable, left traces in the form of laterally extensive seismites characterised by a high concentration of soft-sediment deformation structures (SSDS). Such seismites have been described from Sweden, Ireland, Germany and lately we described Saalian and Weichselian examples from Poland and Latvia (GREBAL project).

Seismites have been reported from almost all sedimentary environments, but particularly from lacustrine/glaciolacustrine successions. Glaciolacustrine sediments are susceptible to subsequent syn-, meta- and postdepositional deformational processes. They can preserve traces of earthquakes in the form of SSDS, such as faults (brittle deformation), load casts (plastic deformation) and clastic dykes (fluidusation). Seismically-induced shock waves that are responsible for the development of SSDS in water-saturated, unconsolidated sediments in the uppermost decimetres of the sedimentary succession are S-waves, which result in alternations of compression and tension within the sediment, thus allowing material to sink into the underlying layer, even if there is hardly any vertical density gradient.

Multiple horizons with abundant SSDS induced by earthquakes caused by glacio-isostatic rebound in fine-grained glacioacustrine sediments were described from Poland and Latvia. Both Baltic countries are characterised low seismic activity. Seismites are characterised by abundant deformations caused by liquefaction and fluidisation. The final morphology of the SSDS in seismites depend mainly on the initial sedimentary setting, the driving force and the duration of the deformable state. The frequency, size and/or complexity of seismically-induced SSDS diminishes with increasing distance from the epicentre.

Palaeoseismic studies commonly depend on the recognition of seismites on the basis of their characteristics, particularly the geometry of the deformations, and on lithofacies analysis. The seismites caused by more than 90% of the historical seismic events are located within 40 km from the epicentre. Most of the SSDS related to earthquakes with a magnitude of 5-7 occur even within a distance of 20 km from the epicentre. Earthquakes with a lower magnitude may also trigger liquefaction, but only in an area close to the epicentre. Thus, the type and size of layers with soft-sediment deformation structures of a seismic origin are a function of the magnitude. The spatial distribution and lateral changes in the type and size of these soft-sediment deformation structures can be used to locate main active faults or the epicentres of deep earthquakes.

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A GLACIOLACUSTRINE GRAVITY-FLOW DEPOSIT WITH ENIGMATIC CLASTS (PLEISTOCENE, W POLAND)

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A glaciolacustrine silty layer of 35 cm thick that was deposited during the Saalian in the Ujście Basin (W Poland) has some enigmatic aspects. The layer has sharp upper and lower boundaries and contains numerous silty clasts with irregular shapes. Some clasts are rounded, whereas other clasts are sub-angular. Their length/width ratio varies from about 1 to about 3, although most clasts seem to be more or less equidimensional. Elongated clasts are positioned more or less parallel to the bedding plane, but some are distributed throughout the silt in an apparently haphazard way; they are present from bottom to top, though somewhat more frequent in the lower part of the layer than in the upper part. The clasts show a tendency to cluster. They consist of unconsolidated, laminated silt. The laminae commonly show a distinct bending, indicating more or less complex deformation before or during transport.

Such a layer does not fit in the general picture of a lacustrine setting as it has not only an overall entirely different lithology, but also because of its extremely bimodal grain-size distribution: cm-sized clasts of unconsolidated silt float in a silty matrix that does not show any traces of internal lamination. The silt in the matrix has a relatively narrow grain-size range, but the clasts vary from a few millimetres to several centimetres.

The only feasible explanation for the enigmatic layer is deposition by a gravity flow. The flow responsible for deposition of this layer must initially have contained almost exclusively fine-grained (silty) material (mud flow), and on its way downslope it must initially have had sufficient erosive capability to pick up parts of the (frozen) laminated silty sediments on the basin's marginal slope. When the inclination of the slope became less, the velocity of the flow diminished, and it lost its erosive capability. The turbulence within the flow was still high enough, however, to keep the silty clasts distributed all over the flow, though with a somewhat higher concentration in its lower part. The turbulence also explains why the clasts show haphazard orientations, which they retained when the flow eventually 'froze'. During the turbulent flow, the individual silty clasts must have bumped against each other. Due to the temperature of the water in the flow, the originally frozen clasts may have become unfrozen at their outer margins, and the collisions with other clasts may have resulted in the bending of some of these clasts and in the somewhat abraded shapes of other clasts.

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EVALUATION OF THE MINERALOGICAL SIGNAL AS A TRACER OF THE DENUDATION OF PORPHYRY-CU MINERALIZED SYSTEMS IN THE SEDIMENT INFILL OF ADJACENT BASINS IN NORTHERN CHILE

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The Atacama Desert in northern Chile, with a mean annual precipitation (MAP) < 10 mm/y, corresponds to the driest place on earth. It comprises a large number of hydrographic basins filled by coarsegrained sedimentary deposits, widely exposed along the Precordillera and western forearc. These sedimentary products mainly come from the erosion of the Precordillera that was initiated during the Eocene-Oligocene Incaic tectonic event and continuing to at least the Middle Miocene and were deposited under arid-hyperarid climate condition, which prevail from the Late Eocene to the present (Dunai et al., 2005). During the time of the infill, the uplift and erosion of porphyry copper and epithermal gold systems contribute with sediments to the sedimentary basin. The Centinela Basin (22°55'S/69°05'W), in which this study is carried, corresponds to a basin adjacent to the Precordillera, Mirador and Esperanza Cu-porphyries and it is filled by five coarse-grained semi consolidated sedimentary units (from oldest to youngest: Esperanza Gravels, Atravesados Gravels, El Tesoro Gravels, Arrieros Gravels and Ratones sediments) each reflecting different climatic and/or tectonic conditions prevailing at the time of deposition. Also, these units contain interbedded paleosoils (calsisols and gypsisols) and exotic-Cu mineralization. These sedimentary units contain abundant resistate minerals that commonly occur associated to the different associations of hydrothermal alteration in porphyry systems. These resistate minerals can help to characterize the events of denudation of porphyry-Cu mineralized systems. Studies performed in North America showed that resistate minerals from erosion of porphyry-Cu mineralized systems are deposited in the adjacent glacial sediments and can be traced using petrographic observations (e.g. texture, size, luminescence) and chemical composition (mainly relationship between major and trace elements). Pizarro et al., (in prep.), using magnetic signal from gravels of Centinela Basin, proposed that the arid-hyperarid conditions of the Atacama Desert resulted in the low degree of Fe-minerals authigenesis or supergene alteration of minerals thus it will help to well preserve resistate minerals such as apatite and zircon that occur within the matrix of the gravel. This project study petrographic features through visible light, scanning electron microscope and cathodoluminiscense, and chemical features by electron microprobe and laser ablation inductively coupled plasma mass spectrometry analysis of apatite and zircon deposited in the coarse grain sediments of Centinela basin in order to characterize the denudation events of porphyries-Cu mineralized systems and evolution of the basin. Also, the correlation between apatite texture, luminescence, and chemical composition and zircon chemical composition with the type and intensity of porphyry alteration offers a potentially fast and effective method to utilize it as an indicator for porphyry mineralization in a range of exploration on gravels deposit.

USING GPR AND PHOTOGRAMMETRY TO AID IN THE CHARACTERISATION OF THE DEPOSITIONAL SETTING AND SPATIAL FACIES VARIABILITY OF AN OUTCROP ANALOGUE FOR A CONTINENTAL HYDROCARBON CARBONATE RESERVOIR GUADIX BASIN, SPAIN)

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The currently active carbonate hydrocarbon fields in Brazil and Angola have generated an increasing interest in the processes affecting the formation of continental carbonate systems, especially in those with microbial deposits (microbialites). The richness of continental carbonate facies and the quality of their preservation in the basins of the Betic Cordillera make these examples significant as case studies for outcropping analogues for hydrocarbon reservoirs.

In this work, several techniques have been applied for the sedimentological and geometrical characterisation of a fluvial tufa depositional system in Southern Spain (Guadix Basin, Betic Cordillera), presented as an analogue for hydrocarbon carbonate reservoirs in continental settings.

The stratigraphical, sedimentological and geochemical data were used to interpret the depositional and diagenetical features of the tufa system and its evolution through time. In the main outcrop, a number of surfaces delimiting sigmoidal sedimentary bodies within the system were identified during field observations.

The initial GPR analysis of the tufa build-up combined with an outcrop facies analysis in the field led to the interpretation of this body as a fluvial barrage tufa, corresponding to a stepped fluvial tufa, where the sigmoids would be the result of an iterative degradation of the original tufa phytoherm, not found in the area possibly due to the erosion by the overlying alluvial fan deposits. The boundaries between sigmoids would correspond to erosive surfaces related to the rising of the base level of small lakes that would have formed downstream.

Once these surfaces were clearly delimited, a digital model of the outcrop was developed by photogrammetry, using an UAV (Unmanned Aerial Vehicle). A georeferenced model of the analogue was obtained, and key boundaries and surfaces were identified and interpreted in the outcrop. The photogrammetry data were also useful to estimate the ideal parameters of these type of geobodies (morphology, size and trends) for their later geostatistic modelling using Petrel software (license kindly provided by Schlumberger).

The high-precision results are combined with previous data to propose a facies model for the outcrop analogue, showing the facies distribution and the trends within each geobody.

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SEDIMENTOLOGICAL CHARACTERISATION OF A PLEISTOCENE FLUVIAL TUFA IN THE GRANADA BASIN (BETIC CORDILLERA, SPAIN)

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The continental carbonates outcropping in the surroundings of the artificial Cubillas dam in Granada are well known by archaeologists as ancient construction materials. A Roman quarry has been identified in the northern margin of the dam, and the ruins of several roman villas and an aqueduct have been located and connected to this quarry of what is called in construction terms “Roman travertine”. It seems that the river Cubillas was also dammed in Roman times, providing fresh water to the inhabitants of the villas located around it. The carbonates appear as an extensive outcrop (approximately 5 km^2) in the confluence between the Cubillas river and the Colomera river. However, although these continental carbonates are recorded in the 1:50000 Spanish geological map, no sedimentological studies have been carried out on the abovementioned outcrop.

In this study, we present data from field observations on the variety of tufa facies identified in the outcrops and their distribution in the tufa system. While there are more laminated facies in the proximal area, in the distal part there is a predominance of medium size coated stems, formed under a flowing water current, showing palaeocurrent directions. The system is interpreted as a fluvial tufa, and its evolution with time is provided.

The tufa sediments, interpreted as Early Pleistocene in age by previous authors mapping the area, are laterally connected to alluvial fan facies formed mostly by Mesozoic carbonate clasts (conglomerates, sands and silts). These deposits are similar in age and geological context to other examples that the authors have already studied in the nearby Guadix and Alcalá Basins, so a comparison among the depositional features and the control on the facies distribution of the three examples is presented.

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SIGNIFICANCE OF RIVER HYDROLOGICAL REGIME IN SOURCE TO SINK ANALYSES

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Based on global modern river discharge analyses, we show that average discharge (Qave) values represent discharge events of very different frequency and magnitude in rivers with different hydrological regimes. Thus, applying Qavg in source to sink analysis (e.g., BQART) may cause an error of multiple magnitudes in drainage basin and sediment yield estimates.

Only rivers with extremely persistent hydrology have normally distributed discharge where the Qave values approach the 50th percentile occurrence (Q50) and can be assigned a specific frequency and magnitude. In such rivers low and high magnitude discharge events differ little from Qave. Such persistent discharge is largely a function of perennial precipitation style that provides a year-round surface water supply, and lacks extreme wet-or dry-seasons. Rivers with variable hydrology have seasonally low base flow conditions (considerably lower than Qave) that are interrupted by a strong wet-seasons (considerably higher than Qave), giving the hydrograph a positive skew, a longer right tail, and a high magnitude excursion from base flow. Even more erratic, ephemeral rivers with extremely low or lack of base discharge and intermittent high magnitude flooding events have extremely positively skewed discharge frequency distributions. These hydrographs are best fit with highly asymmetric lognormal distributions or in some examples approach exponential distributions with very high frequency of low-magnitude discharge events and increasingly infrequent high-magnitude discharge events. Qave in such rivers represents a flow event that likely only occurs momentarily, and is a transient flow state that inadequately characterizes either base-flow or flood conditions.

Comparison of hydrographs of modern rivers shows that Qave in a river with persistent hydrology can be 100 times larger as compared to a river with erratic hydrology with the same drainage basin size. This implies that using Qave we are highly likely to consistently underestimate the drainage basin size, the efficient discharge, and thus the river's capacity for sediment yield in rivers with erratic and highly seasonal hydrology. This efficient discharge is also the channel forming discharge and thus determines channel dimensions that we utilize in the ancient record as a key parameter in drainage basin or sediment yield estimates. Channel-forming discharges and thus channel dimensions have values close to Qave only in rivers with very persistent hydrological regime. In rivers with highly seasonal or erratic hydrology, the efficient channel forming discharge (bankful flow) is a considerably higher magnitude flow and is likely close to Q99 rather than Qave.

River hydrology is largely driven by climatic conditions, and thus a function of precipitation and snowmelt, aided by hydrological connectivity and groundwater flow. Also here, we commonly utilize average values in our interpretations of environmental drivers, and there is a tendency to link lower sediment yields to lower average precipitation (increased aridity). However, rivers with highly seasonal or erratic hydrology occur in arid climates and produce efficient discharges that may be multiple orders of magnitude higher than their Qave, and are thus likely to have high sediment yields, especially when paired with increased hydrological connectivity such as reduced vegetation cover.

DID EARLY EOCENE RIVERS HAVE EXTREME HYDROLOGICAL REGIMES?

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Paleo-discharge analyses of the California paleoriver that drained the Cordilleran Magmatic Arc in North America indicates an extremely erratic (ephemeral) hydrology with highly variable discharge. The California paleoriver had a catchment area of 146,961 km^2, and it accumulated a 250 x 200 km fluvial megafan in the Uinta basin in Utah. The sedimentary facies indicate dominant deposition from Froude supercritical flow and abundant suspension deposition of sand and even gravel-sized sediment. Well-developed barforms such as point bars or braid bars are missing and instead low-angle, thick (up to 10-12 m) downstream accreting sheets form the macroforms. In-channel bioturbation and pedogenic modification indicates that the channels were intermittently sustainably dry. The thick accretion sets and the high degree of channel amalgamation indicate rapid local channel bed aggradation that resulted in frequent avulsions. Collectively the sedimentological features indicate deposition during high magnitude floods with no post-flood reworking, and intermittently dry river beds.

Global modern river discharge analyses show that in modern rivers with increasing discharge variability the recurrence interval of geomorphically effective discharge, i.e. the channel forming discharge, also increases. Studies of the recurrence interval of bankfull discharge in modern rivers suggest that 1-2 years is a good benchmark for rivers with perennial and persistent hydrology, but this recurrence interval increases in rivers with high discharge variability. Recurrence intervals of bankfull discharge of 4-6 years are documented for dryland rivers in the Australian Outback, and in the Burdekin River km-scale barforms are documented to be in geomorphic equilibrium with 10-15 years scale flood events.

The sedimentological features suggest that the California paleoriver deposits were in geomorphic equilibrium with 50-100 years flooding events. In such rivers there is no base flow or the base flow is too low to carry sediment or modify channel morphology, and thus geomorphically efficient discharge only occurs during high magnitude and infrequent flooding events.

A key control on river hydrology in addition to the climatic conditions is the river's size. Base-flow conditions in larger river systems are increased by the integration of catchments of variable hydrological connectivity (sensu Bracken and Croke, 2007) and inflow from relatively larger groundwater pools. The median predicted catchment area for the California paleoriver is more than 30% large than any modern river classified as having erratic hydrology, as based on worldwide river gauging data.

Thus the California paleoriver system represents an endmember-example of flood-dominated fluvial system, suggesting that this flood-dominated fluvial style with prolonged phases of channel abandonment is linked to early Eocene extreme climatic forcing.

ORIGINS OF THE QUATERNARY MARSHES ON THE COASTAL WATERSHEDS OF THE ENGLISH CHANNEL: EXAMPLE OF THE MARSH OF VIMONT (NORMANDY, FRANCE)

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In the Pleistocene, the river system incised the substratum during many glacial / interglacial cycles, then during the sea level rise of the Holocene, the marsh systems developed in the coastal domain, filled by clay-peat thick series. In the coastal watershed of the English Channel, the Orne and the Dives are the main rivers that have shaped reliefs between the Campagne de Caen in the West and the hills of the Pays d'Auge in the East. The main marshes of the Bessin coast are, from East to West, the marshes of the Dives, the Seulles and Carentan. In the downstream of the Dives, the marshes of the Dives and Vimont present a clay-peat filling of Holocene age. These last marshes correspond to a depression located upstream of the front of the callovian cuesta of the Pays d'Auge and hollowed out in the calcareous bathonian series of the Campagne de Caen. The marshes of Vimont extend towards those of the Dives by a cluse (transverse valley) in the cuesta. The thickness of Holocene deposits reaches more than 20 meters in the Dives estuary and less than 2 meters in the Vimont marshes located about 15 kilometers upstream. The marshes of Vimont are located downstream of the Muance which is fed by resurgences of the Bathonian aquifer.

These marshes cover the Norman bathonian aquifer which presents nowadays processes of natural denitrification. In order to understand the origin of these trough morphologies dug between the end of the Pleistocene and the beginning of the Holocene, and the modalities of their filling, a 80 meter drilling crossed the Quaternary series and the Dogger limestones. A multidisciplinary, geological and geomorphological study of the sector completed this search for the origin of the marshes of Vimont. These marshes are located in a bowl about 5 kilometers wide and 10 kilometers long, dug in the limestones of the upper Bathonian. These limestones are cemented in contact with the overlying quaternary series, forming a semi-impermeable wall. The N70-N80 orientation of the bowl is limited to the East by the reliefs of the callovian cuesta. It is also located at the right of a synformal structure in the Bathonian limestones and the callovian marls, put in place during alpine deformations. The depression is a sedimentary trap that favors the establishment of the Vimont marsh in the Holocene.

The origin of the marshes of the coastal watershed of the English Channel is both structural, sedimentary and diagenetic. The Variscan and Alpine structural heritages controlled the shaping of the reliefs and the establishment of the pleistocene drainage network in the coastal watershed. The bathonian palaeogeography explains the variations of facies, the modalities of the Jurassic transgression explain the recurring presence of transgressive marly facies and sedimentary geometries favorable to the presence of reservoirs, in the Bathonian limestone series. In the Tertiary, the continental alterations of the Jurassic limestone cover are at the origin of the carbonate cementations and ferruginous rubefactions described in the carbonated reservoirs.

SPATIO-TEMPORAL VARIABILITY IN THE DISTRIBUTION OF BIOGENIC PARTICLES OVER A COOL TEMPERATE CARBONATE INTERTIDAL FLAT (MONT SAINT MICHEL BAY, FRANCE)

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Coastal barriers represent around 15% of the world's oceanic shorelines, occurring in energetic, wave-dominated environments, and play an important role as early warning indicators of environmental changes. They are typically composed of coarse-grained siliciclastic particles, but in many cases biogenic carbonates also represent a significant proportion of the bulk sediment.

Shelly chenier ridges are lag-concentrations of mollusc skeletal remains separated by prograding intertidal mudflats. They have been identified along several non-tropical coasts, such as U.K., or western Korea, among others. This study focuses on shelly cheniers of the hypertidal Mont Saint Michel bay, which is located within the cool temperate shallow carbonate NormandyBrittany Gulf (western English Channel).

Previous works have focused on the hydrodynamic behaviour of biogenic particles with flume tank experiments, and on the internal architecture of cheniers imaged by sub-surface radar. The aim of this study is to focus on 1) meso-scale spatial variability in the distribution of mollusc skeletal remains across the 5-km wide intertidal mudflat, and 2) identify the processes involved in the spatial distribution of cheniers along the coast.

A bathymetric survey of the intertidal flat was carried out in 1957 with a mono-beam echo sounder. More than 4500 soundings have been digitised and interpolated to reconstruct a spatially-explicit bathymetry of the study area at that time, which was compared with a LiDAR survey carried out in 2002. The 1957-2002 sediment budget is weak but globally positive (+13 cm). Difference bathymetry map shows a cross-shore pattern of alternating ca. 1 km wide corridors of erosion (up to50 cm) and accretion (up to +50 cm). Erosion corridors coincide with areas of chenier development on the coast, as evidenced by sets of aerial photographs taken between 1947 and 2014.

Molluscs have been sampled in the first 5 cm of surface sediment at 25 stations scattered along 5 cross-shore transects corresponding to contrasting values of sediment budget. Live and dead individuals (> 1mm) have been sorted, identified, counted and weighed separately. Bivalve molluscs account for more than 95% of the biogenic carbonate particles found on the intertidal mudflat. Short-lived intertidal species clearly dominate both the live and death assemblage, including Cerastoderma edule, Macoma balthica and Scrobicularia plana. Diversity of the live assemblage is very low (6 species), resulting in a poor live-dead agreement related to incorporation in the death assemblage of subtidal species transported out of habitat (Abra alba), and to time-averaged accumulation of rare taxa, in accordance with previous works. High amounts of fragmented shell hash in surface sediments (1 to 2 kg.m^{-2}) were found in erosion corridors. These results suggest that wave and current propagation across the intertidal flat is focused along corridors, favouring the fragmentation of shells and their coastward transportation, and leading to preferential areas of chenier accumulation. High-resolution numerical hydrodynamic modelling is now being tested to identify the factors controlling corridor pattern of propagation.

ARCHITECTURE OF THE SAND-RICH TURBIDITIC SYSTEM OF MOTTA SAN GIOVANNI'S FORMATION: A NEW INSIGHT IN THE PETROLEUM SYSTEM POTENTIAL OF THE CALABRIAN MIOCENE ?

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On the east side of the Aspromonte (Calabria, Italy), the upper Miocene deposits of the Crotone basin (San Nicola formation) are known for their natural gas productivity (Luna gas field, Ionian Sea). The San Nicola formation presents clastic deposits from littoral to shallow water environments. On the other hillside of the Aspromonte, through the west, the upper Miocene shows characteristic deep-sea clastic sediments, interpreted as a turbidite system (Motta formation, Serravalian-Tortonian-Lower Messinian). The Motta San Giovanni's formation took place in an extensional context impacting Calabria during the entire Miocene. Normal faults affect all the deposits from the crystalline basement to the middle Miocene series, generating a tilted blocks system. The Upper Miocene Motta San Giovani formation onlaps directly the hardground at the top of the calcarenite of Floresta (middle Miocene). The Motta San Giovani formations contain a basal 140 meter-thick clay units and an upper 200 meterthick sandstone units. These sandstones are the subject of this sedimentological high-resolution study. The Motta sandstones exhibit a succession of normal-graded sandy gravity facies with basal erosive surface. Sandy bodies have channelized geometries and are individualized by thin clayed layers. The Motta sandstones propose a wide range of sedimentary facies from massive sandstones with granules to fine well-sorted sandstones. Theses facies follow the classification of Mutti for the deep-sea gravity environments (F1 to F8 facies), providing evidence for proximal to distal deposits and helping to identify channel-levees geometries. The granularity at the basis of each sequences reflects changing in the volume and energy of the gravity flows. The high quality of the outcrop allows to follow the migration of the stacked channel bodies pinch outs over the top of the lower clay units. The frequency of the vertical sections (about 10 sections for 800 meters long outcrop) highlights variations in channels thickness through time. The high-resolution vertical and horizontal sedimentological analysis of the genetic sequences highlights the high variability and complexity of the distribution of the sedimentary facies, suggesting that this turbidite system recorded at least two 3rd-order transgressive-regressive cycles. Some channel locations are determined by normal faults and show thickening at their contact, providing evidences of an active synsedimentary activity during the progradation of the system. This architecture in two distinct superimposed systems would be linked to regional syn-tectonics events through the upper Miocene and could favour trap formation in this petroleum system analogue. The Motta sandstones could represent lateral variations of the Miocene San Nicola formation (Crotone basin) and could be of a great help in understanding of the structuration of the Calabrian margins. Furthermore, Motta San Giovanni's outcrops constitute a magnificent reservoir analogue of turbidite system in intense extensive tectonic.

CALABRIAN ARC AND AD 365 CRETE EARTHQUAKE SEISMO-TURBIDITES IN THE IONIAN SEA

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In the Ionian Sea, one of the most seismically active regions in the Mediterranean, subduction is commonly associated with uplifting of coastal mountains, enhanced erosion, and seismic activity along the Calabrian and Hellenic Arcs, which thus results in repetitive mass failures on the basin slopes.

Five turbidites were deposited during the last millennia in a wide area of the confined basin floor of the Ionian Sea. They have been analysed to determine the seismic shaking and tsunami wave erosion processes that generate seismo-turbidites (ST). Using radiocarbon and chronostratigraphic age models, the thickest recent turbidites are correlated with major Calabrian Arc earthquakes (AD 1908 Messina, AD 1693 Catania, and AD 1169 Eastern Sicily). Textural, micropaleontological, geochemical and mineralogical signatures of seismo-turbidites have been used to define a conceptual depositional model for the development of tsunamigenic earthquake-triggered seismo-turbidites in a confined basin. This model illustrates the deposition of stacked turbidites, homogenites, laminites and tsunamites, as a response to the complex succession of sedimentary processes following seismic shaking: multiple slope failures; waning flows of the turbidity currents; water mass seiching; and tsunami backwash erosion.

Some of the turbidites observed in the deep basins are thick and prominent on seismic records because of the acoustic transparency of their upper structureless, homogeneous mud layer. Our high-resolution study of the most recent of these megabeds, the Homogenite/Augias turbidite (HAT), provides key proxies to identify and date pelagic sediments deposited following the catastrophic HAT event. Radiometric ages in an area greater than 150,000 km^2, indicate that the different Mediterranean "Homogenite deposits" described in the literature are, in fact, synchronous and were deposited during a single basin-wide event within the time window AD 364–415. Unlike interpretations which relate this turbidite to different triggering events, including the Santorini caldera collapse in 1627–1600 BC, the seismo-turbidite can be correlated with a catastrophic basin-wide tsunami sourced from the AD 365 Crete megathrust earthquake. Correlation of the single-event HAT over a wide area of the Mediterranean Sea, suggests that the AD 365 Crete earthquake and tsunami, which caused historical devastating coastal effects, also produced widespread massive sediment remobilization. An older similar megaturbidite was deposited after 14.590±80 yr BP, implying a long recurrence time for such extreme earthquake events in the eastern Mediterranean Sea.

The confined basins of the Mediterranean Sea, with high uplifting coastal mountain ranges, amplify seismically induced sedimentary processes. The HAT is the thickest and largest seismo-turbidite tsunamite yet known and can thus be used to define proxies to reconstruct super-quake recurrence time, in other megathrust regions.

PROCESS VARIABILITY AND DEPOSITIONAL ARCHITECTURE OF THE ELDS IN THE FIRSOFF SOUTH CRATER (ARABIA TERRA, MARS)

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The genesis of the Equatorial light-toned sulfate bearing layered deposits (ELDs) in Arabia Terra has long been debated with many processes/environments proposed (including aeolian, airfall, lacustrine, volcanic, playa, spring deposits and combinations among these, stratigraphic relations with the clay bearing possible fluvial deposits) and different depositional geometries inferred (with implications of different degrees of erosional overprint).

Because of the position of Arabia Terra as a sort of low-dipping connection between Highlands and Lowlands, the depositional environment(s) of the ELDs might have implications at a supra-regional scale either in term of lateral transitions and controls on deposition. Moreover, western Arabia Terra is also an area of interest for ExoMars Landing Site selection.

We are continuing our work aimed at unraveling the depositional processes, stratigraphy, geometry and composition of the ELDs in the area surrounding Firsoff crater. Here ELDs are well exposed both in the craters, including the 80 to 100 km large ones such as Crommelin and Firsoff to some smaller ones roughly 20 km across, and in the plateau. In particular, here we focus on the ~60 km large Firsoff south crater as mounds, light-toned and dark-toned layers are exceptionally well-exposed at this site and a HiRISE stereo pair enables investigating their mutual stratigraphic relations throughout the whole crater.

The thickness of the sedimentary infill can be roughly estimated as 1 to 1.3 km, with maximum values around the crater rim. These deposits gently drape (dip generally less than few degrees) and onlap the Noachian Plateau Sequence and are disconformably covered by a cap rock. The sedimentary infill consists of three units which are interlayered both vertically and laterally. The layers appear to be few meters thick at the scale of the available resolution. They consist of light-toned and darktoned layers where the light-toned ones appear to be more resistant to weathering and erosion even if the entire succession is heavily affected by aeolian erosion as shown by numerous yardangs. The light-toned layers are quite irregular, disrupted in a meter-scale polygonal pattern and dish-shaped depressions, with sinuous locally rimmed margins and do not show any evidence of cross-bedding while the dark-toned layers are frequently covered by a recent aeolian dark mantle either showing dunes or not. Where visible, these layers appear smooth and fill the irregularities of the lighter ones. Locally, hundreds of meters large and tens to hundreds meter high mounds form clusters, sometimes aligned along possible fissure ridges. The mounds sometimes display an apical pit. Even if not in this crater, the ELDs in the nearby craters and plateau have been shown to contain polyhydrated sulfates.

We suggest that the ELDs primary deposition was controlled by groundwater upwelling sourcing from mounds and fissure ridges and depositing in spring deposits and playa settings. ELDs lightertoned layers might represent evaporites (polygonal pattern, draping geometry, syn-to syn-post depositional morphologies) while darker-toned layers might reflect a clastic fluid-expulsion (smooth, filling irregularities of the lighter-toned layers).

THE ZAMBEZI SEDIMENTARY SYSTEM: A RECORD OF THE VERTICAL MOVEMENTS OF THE MOZAMBICAN MARGIN SINCE CREATCEOUS TIMES

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The Mozambique margin is an oblique to transform margin which houses one of the largest African turbiditic. The turbiditic system is related to the Zambezi delta which recorded more than 12 km of sediments deposits with little destabilizations. It is bounded by two fracture zones: to the West the Mozambique ridge and to the East the Davie fracture zone which controlled the southward migration of Madagascar during the early Cretaceous. Onshore the Zambezi catchment drains a large domain from the South African plateau to the southern part of the East African rift system. Linked to several vertical movements and flexures the Zambezi catchment evolved since early Cretaceous times. Four main episodes have been identified: 1) Early Cretaceous – Paleocene, 2) Paleocene – Oligocene, 3) Oligocene – Pliocene, 4) Pliocene – Present times. Our objective is to realise a whole study (paleogeography, thickness maps, sedimentary volumes and budget) of the Zambezi / North Limpopo system from the vertical movement recorded onshore to the sedimentary deposits both deltaic and turbiditic since early Cretaceous times, within a well constrained climatic frame. Our first objective was to perform a new biochronostratigraphic framework based on nannofossils, foraminifers, pollen and spores on the cuttings of three industrial wells in order to produce for the Zambezi delta a new strong age model and a continuous paleoclimatic frame evolution. The second target was to recognize the Zambezi/Limpopo different steps of growth using a dense seismic data-set (industry data and new academic data). Onshore a landform study from the highest plateau to the present day pediplain was carried out on the Zimbabwe plateau to the North Malawi area (Tukuyu) in order to better constrain the relative sea level variations which are a proxy of the deformation. Six step of the Zambezi system evolution were identified:

• Late Jurassic – Late Cretaceous (Albian): the Zambezi delta is defined by a slight slope with reduced height clinoforms.

• Late Cretaceous – Cenozoic: after a major transgression occurring during Cenomanian times, the system Zambezi/Limpopo – Save prograded. The location of two main depocentres traduce two sedimentary supplies: from the Bushveld and the paleo Zambezi.

• Early Paleocene – Late Eocene: A second main transgression flooded the present day coast allowing the initiation of a carbonate platform (the Cheringoma limestones).

• Oligocene – Miocene: birth of the present day Zambezi delta, tied with (1) a tilt of the north Mozambican margin during the Oligocene to the middle Miocene related to the southward migration of the East African rift system, (2) the progressive Zambezi headward erosion leading to the capture of the Luangwa river located in the middle Zambezi area.

• Miocene – Pliocene: initiation of the Zambezi channel and an export increase of sedimentary materials towards the most distal part of the deep sea fan.

• Pliocene – Present day: this period is defined by the major catchment evolution of the Zambezi which doubled with the Victoria Falls capture.

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ORIGIN OF SPECTACULAR FIELDS OF SUBMARINE SEDIMENT WAVES AROUND VOLCANIC ISLANDS: HOW TO DISTINGUISH ERUPTION-FED SUPERCRITICAL FLOW BEDFORMS FROM SLOPE FAILURES

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Silicic caldera-forming eruptions and submarine landslides on volcanic islands are some of the highest sediment flux events on Earth. They can move several to hundreds of cubic kilometers of material over hours to days, and play a major role in volcanic island growth and decay. These events are extremely dangerous, both to local populations, and by generating far-travelling tsunami. It is thus important to understand how large eruptions and landslides are recorded by the seafloor morphology and deposits on volcanic island flanks. Spectacular fields of bedforms have been recognised recently on the submerged flanks of volcanic islands, at multiple locations worldwide. These fields of bedforms can extend for over 50 km, and individual bedforms are hundreds of meters to 1.5 km in length, and 10-150 m in height. The origin of these bedform fields was poorly understood. Here, we show that bedforms result from eruptionfed supercritical density flows (turbidity currents) in some locations, but most likely rotational landslides at other locations. General criteria are provided for distinguishing between submarine bedforms formed by eruptions and landslides, and emphasise a need for high resolution seismic datasets to prevent ambiguity. Bedforms associated with rotational landslides have a narrower source, with a distinct headscarp. They are more laterally confined, and their internal structure does not migrate upslope. Eruption-fed density currents produce wide fields of bedforms, which extend radially from the caldera. Internal layers imaged by detailed seismic data show that these bedforms migrated up-slope, indicating that the flows that produced them were Froude supercritical. Due to the low density contrast between interstitial fluid and sediment, the extent and dimensions of submarine eruption-fed bedforms is much greater than those produced by pyroclastic density currents on land.

THE MICROPALEONTOLOGICAL SIGNATURE OF THE END OF THE MESSINIAN SALINITY CRISIS IN THE CENTRAL MEDITERRANEAN BASINS: PALEOGEOGRAPHIC INFERENCES

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The Messinian uppermost sediments and the Zanclean lowermost ones from nine DSDP-ODP sites in the Western Mediterranean (from the Alboran Sea to the Tyrrhenian Sea) have been analysed at high sampling resolution for calcareous nannofossils, planktonic foraminifers, ostracods, dinoflagellate cysts and pollen grains. Biostratigraphy is specified by the occurrence of microplankton markers, especially by the first occurrence of Ceratolithus acutus (5.35 Ma) and foraminifers indicating the base of the Zanclean (Sphaeroidinellopsis acme at 5.33 Ma). This study provides detailed information on the paleoenvironmental conditions of deposition of the Upper Evaporites (i.e. the Upper Unit, UU), which include some halite layers.

UU deposited in a continuous marine setting but in a relatively shallow context according to the poor assemblage of calcareous microfossils (foraminifers and nannofossils) and relatively near to the coastline according to the dinoflagellate cyst assemblage. Pollen flora, rich in herbs and particularly halophytes, also supports a coastal paleoenvironment. It is clear that the Western Mediterranean Basin received a continuous influx of oceanic waters during the UU deposition. A similar process may be considered for the deposition of the thick underlying Mobile Unit.

Several samples are rich in Paratethyan dinoflagellate cysts, displaying successive intrusions of brackish waters from the Paratethys, known as Lago Mare episodes. Such episodes are also characterized by dry climatic conditions, that discards the hypothesis of humid phases often proposed to explain a Lago Mare event. In fact, there were three Lago Mare events: the oldest one at the end of the first step of the Messinian Salinity Crisis (evaporites in the peripheral basins) just before 5.6 Ma, the second one at the end of the second step of the crisis (evaporites in the central basins) just before 5.46 Ma, the last one just after the complete marine reflooding of the Mediterranean Basin just after 5.46 Ma. The first and third Lago Mare episodes are shown to result from high sea-level exchanges between the Paratethys and the Mediterranean. The second Lago Mare episode may have been caused by the collapse (by erosion) of a segment of the Hellenic Arc, which could have released Paratethyan waters probably stored within the isolated Aegean Basin during the peak of the crisis.

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EARLY NEOPROTEROZOIC BIOSTRATIGRAPHY: LIFE BEFORE THE CRYOGENIAN GLACIATIONS

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Correlation of pre-glacial Neoproterozoic strata has traditionally relied on chemostratigraphy. Recent fossil discoveries and new radiometric constraints on fossiliferous strata, however, make biostratigraphy increasingly useful for correlation and subdivision of early Neoproterozoic time. Trachyhystrichosphaera aimika, known from more than 20 assemblages worldwide, appears to be diagnostic of Tonian time, and the distinctively wrinkled and widespread *Cerebrosphaera globosa* (=*C. buickii*), appears to be diagnostic of the time interval between the Bitter Springs and Islay carbon isotope anomalies (i.e., 789–740 Ma). Lanulatisphaera laufeldii, characterized by an anastomosing and branching network of filamentous processes and found in nine assemblages worldwide, also has the potential to be an index fossil for post-Bitter Springs, pre-Islay time.

The youngest fossils to occur in pre-glacial strata are the vase-shaped microfossils (VSMs), distinctive fossils that have been found in more than a dozen successions, often in high abundance, in a variety of preservational modes and lithofacies. Five species in particular, *Cycliocyrillium simplex*, *C. torquata, Bonniea dacruchares, B. pytinaia*, and *Melanocyrillium hexodiadema*, are common, easily identifiable, and cooccur in assemblages that span the onset of the Islay anomaly, ~740 Ma. These could be used in combination with that anomaly to define the Cryogenian GSSP.

Finally, we report the discovery of flattened, spindle-, shield-, and club-shaped structures composed of kerogen and phosphate that are stratigraphically associated with VSM assemblages in the Black River Dolomite of Tasmania, the Beck Spring/Kingston Peak transition of Death Valley, the Russöya Member of Spitsbergen, and, possibly, the Chuar and Uinta Mountain groups of the western United States. Similar structures have also been reported from VSM-bearing rocks in the Visingsö Group. We tentatively interpret these as possible mineralized protistan scales and suggest that these could also serve as markers of latest Tonian/ early Cryogenian time.

DEVELOPMENT AND DECEASE OF THE SO-CALLED FRASNIAN REEFS IN THE FRASNIAN OF BELGIUM

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The Belgian middle Frasnian is famous for a long time for limestone corps interpreted as typical stromatoporoid-coral reefs. However, large quarries now display full section in some of these “reefs” allowing to document their pattern, stratigraphic evolution and their final decease relating to the beginning of the upper Frasnian crises. It appears that only the core of these limestone corps is really composed of boundstone, most of the rest being composed of subtidal bioclastic deposits showing slumps and palaeoslopes of 25-30° and capped by shallow subtidal and intertidal lime mudstone.

The sequence stratigraphy of the Middle and Upper Frasnian was revised and has allowed to establish that the development of these limestone corps was well correlated with third-order sequences. During the Middle Frasnian, the onset and vertical growth of the built core (few hundreds m wide) of the three levels of “reefs” (“Arche”, “Boverie” and “Lion”) corresponded to the transgressive system tract (TST) of the sequences. During the high-stand (HST) and the falling-stage system tracts (FSST), they evolved to progradant carbonate platforms, 1 – 3 km wide and up to 140 m high (including the biohermal core), in which boundstone are replaced by packstone – grainstone, then by shallow-water and interdital mudstone (FSST). There is never evidence for the development of atolls rimmed by stromatoporoid-coral barreers, as it is usually suggested. The final emersion of these reef-limestone platforms in the distal areas of the basin, and of the carbonate platform in the proximal areas, stopped the carbonate production until the following transgression-regression sequence. The last (third) middle Frasnian regression is correlatable with the end of the Lion “reef” and of the Middle Frasnian type “reefs”.

During the beginning of the transgression of the first of the two recognized upper Frasnian sequences, was the first crisis affecting corals and stromatoporoids, probably due to a global fall of the atmospheric oxygen. Subsequently the carbonate production never recovered as previously. Reddish microbial mudmounds (“Petit-Mont type buildups”), grew during the TST and the HST of this first upper Frasnian sequence. They are smaller than the previous corps, reaching up to 300 m wide and 80 m high. Their growth was dominantly vertical and there is no marked progradation during the HST. During the FSST of the sequence, shallowwater mudstones and stromatolites developed on their top, then their emersion stopped their development. During the last Upper Frasnian sequence the extension of anoxic-dysoxic facies prevented the development of large buildups, and only 1 to 2 metres-wide micro-mudmounds have so far been recorded.

STRATIGRAPHIC MODELLING OF MIOCENE COMPOUND CLINOFORMS OF THE NEW JERSEY SHALLOW CONTINENTAL SHELF

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The New Jersey passive margin with well-developed clinoforms has long been a key location for past sea-level reconstructions and an end-member of passive margin sedimentary geometries. Recently, IODP Expedition 313 brings new insights on the facies architecture of Miocene clinothems preserved on the New Jersey shallow continental shelf feeding discussions on their depositional model and stratigraphic organization. This paper uses Dionisos, a process-based numerical modelling software, to reproduce the geometry and the architecture of Miocene clinothems. The objective is two-fold: (1) validate the hypothesis that a depositional model involving compound clinoform geometry (i.e. paired subaerial and subaqueous delta clinoforms) explains the facies architecture of Miocene clinothems, (2) evaluate the amplitude of sea-level fluctuations required to produce such a geometry.

Simulations that consider waves and river discharge as equal contributors in the transport of sediment succeed in reproducing most key aspects of the Miocene clinothems: the seismic architecture (dip and geometry of reflectors), the stratigraphic architecture (systems tracts stacking patterns), the facies architecture (spatial distribution of facies), and the scale and geometry of the clinoforms (dip of the shelf, thickness of the sequences and height of the clinoforms). The action of waves exerts the prime control on the geometry of the compound clinoforms, which is characterized by a sandy subaerial delta at the shoreline feeding a muddy subaqueous delta clinoform that progrades on the shelf below wave base. Our results support recent depositional models of subaqueous deltas characterized by deepwater mud-dominated material on the topsets and toesets, and shoreface sand-dominated material on the rollover and foresets. This supposes that topsets muds were emplaced during highstand times, while the rollover sands mark lowstand times in clinothems, which are composed of four systems tracts (TST, HST, FSST, LST) building individual T-R sequences. Major seismic bounding surfaces (i.e. the clinoforms) correspond to Maximum Regressive Surfaces –MRS, which landward of Expedition 313 coreholes, merge with the sequences boundaries –SB– recognized in onshore coreholes.

According to this reappraised stratigraphic model and based on Expedition 313 age framework, the New Jersey clinothems arrange in third-order, ~1.2 Myr-long megasequences. Those megasequences likely correspond to obliquity cycles that control the growth and decay of large Antartica ice sheets in the Miocene. A set of simulations was run to test this hypothesis and evaluate the amplitude of sea-level fluctuations. The best-fit simulation corresponds to a sinusoid-like curve characterized by 1.2 Myr-long cycle with amplitude of c.60 m. Even though those values are consistent with astronomical and paleoclimate estimates, such sealevel curve differs from the ones proposed in the literature.

THE NICOBAR SUBMARINE FAN AND RELATIONSHIP WITH THE BENGAL FAN: PRELIMINARY RESULTS FROM IODP EXPEDITION 362, INDIAN OCEAN

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The Bengal-Nicobar Fan has been long-studied to investigate possible links between Himalayan tectonics and the Asian monsoons. Despite the many DSDP, ODP, and IODP expeditions in the region, the Nicobar Fan is largely undersampled, even though it contains key information on the tectonostratigraphic evolution of the eastern Indian Ocean. In contrast to the Bengal Fan that records Holocene sediment gravityflows (SGF), the Nicobar Fan, lying east of the Ninetyeast Ridge, is inactive because subduction of the ridge starting in the Late Pleistocene blocked the sediment supply from the north. IODP Expedition 362 (AugustOctober 2016) drilled two boreholes within the sedimentary cover of the Indian Ocean Plate offshore from the north Sumatra subduction zone to investigate the role of input materials in the seismogenesis of megaearthquakes. Here, the 1-to-5 km-thick sedimentary succession comprises a basal pelagic layer overlain by sediments of the Nicobar submarine fan. Drill sites are located at 3°N 91°E, ~ 250 km southwest of the subduction zone, on the eastern flank of the Ninetyeast Ridge where the input section is ~1.5 km thick. Sites U1480 and U1481 were drilled, cored and logged to a maximum depth of 1500 m below seafloor (mbsf), and reached the 60-70 Ma igneous oceanic crust of the Indian plate. The recovered sediments represent a nearly continuous Late Cretaceous to Recent deep-marine sedimentary section that consists of silicilastic sediments deposited from various SGFs (including turbidity currents and debris flows), interpreted as Nicobar Fan, underlain by a diversity of abyssal-plain environment sediments containing essentially hemipelagic, pelagic, tuffaceous and igneous lithologies overlying ocean crust. The Nicobar Fan represents > 90% of the input section on the drill sites and is characterized by a succession of muddy to sandy SGF deposits, including abundant plant-fragment-rich debrites, with rare interbeds of calcareous mud. Sediment accumulation rates reached 100-400 m/Ma in the late Miocene to Pliocene (25-1250 mbsf), but were considerably reduced since ~1.6 Ma (5-20 m/Ma). Underlying the Nicobar Fan, an Oligocene-Miocene unit composed of siliciclastic mud and rare sandy SGF deposits (turbidites as deep as ~1500 m in Site U1481) may record the early stages of the fan in the abyssal plain. Sediment accumulation rates are low (2-15 m/Ma) and the amount of siliciclastic material tends to decrease with depth. Below this, the Late Cretaceous to Oligocene pre-fan unit comprises a suite of pelagic sediments (tuffaceous mudstones, chalk, calcareous mudstones) characterized by a slow (1-5 m/Ma) and erratic (many hiatuses) sedimentation, interbedded with several magmatic intrusions and extrusions. Expedition 362 demonstrates that the Nicobar Fan was active between ~1.6 and ~9 Ma, and possibly since ~30 Ma. The observed mineralogical assemblage of the SGF deposits is consistent with a provenance from Himalayan rivers and the succession is interpreted to represent different stages of fan development from initiation to abandonment. Expedition 362 results will enable direct comparison between the Nicobar Fan and records of sedimentation elsewhere in the Bengal and Indus Fan and provide a holistic view of the Indian Ocean fan system history.

PROVENANCE, SEDIMENT ROUTING AND FLUVIAL ARCHITECTURE IN THE LOWER EOCENE CORÇÀ-CASTISSENT FORMATIONS (SOUTH-CENTRAL PYRENEES, SPAIN)

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Understanding how sediments are eroded, transported and deposited by rivers is fundamental to identify the relationship between drainage dynamics and the filling history of sedimentary basins. Stratigraphic architecture of fluvial systems provides information about relief history and sediment bypass, and sediment composition is controlled by the nature of sediment sources, climate, and sediment pathways. Unravelling their signature is critical to understand modern sediment dynamics and to generate accurate paleo-reconstructions.

The Corçà and Castissent Formations are two fluvial units that overlie marine to transitional sediments within the Àger-Tremp-Graus basin (Ypresian, south-central Pyrenees, Spain). Excellent exposure and preservation make them ideal to study fluvial architecture in a diachronously subsiding basin, and the development, linkage and time-correlation of lower Eocene sediment routing systems. In this work, sedimentary, architectural and provenance data are presented and used to determine sediment transport pathways over time and to establish chrono-tectono-stratigraphic relationships between the Àger and Tremp sub-basins. A persistent NW-SE basin axis orientation is indicated by the onlap geometries of the Corçà and Castissent strata onto the underlying stratigraphy. A series of north-striking structures where deposits display growth strata are also observed, suggesting that their geometry and evolution potentially affected sediment transport pathways through time. Facies analysis combined with fluvial architecture and paleoflow indicators point towards a relationship between northwestward sediment input and fault orientation, and indicate that both Corçà and Castissent formations were strongly affected by the syn-sedimentary and diachronic movement of the Montsec thrust and its associated local structures. Equivalence in lithology, facies and paleocurrents suggests a correlation between these formations as part of a larger fluvial system, which was laterally connected with a deltaic complex feeding the lower Hecho Group turbidites, further to the west.

Compositional point counting analysis has allowed defining different petrofacies according to the relative amounts of quartz-feldspar, lithic and carbonatic grains, and associated with the dominance of different source areas. A southeastern source for the Corçà Fm was located in eastern sectors of the Ebro Massif, and a similar signature in the Castissent Fm indicates a temporary connection existed across the Montsec high at that time. However, when moving basinwards (to the west), the Corçà Formation is not exposed and the southern source signature in the Castissent Formation is only recorded by sporadic irruptions. Here it is progressively replaced by a quartzo-feldspathic system, attributed to a local northern input. This complex source interaction decreases upwards as carbonate-rich northern-eastern-sourced systems become more established, with potential implications in the composition of coeval turbidite systems in the Ainsa-Jaca basins.

Results of this work demonstrate an interaction of several feeding systems and different sediment sources occurred in the South-Pyrenean Foreland Basin during the Ypresian, coeval with the diachronic development of major tectonic structures. This study therefore cautions against using techniques such as thermochronologic proxies for regional palaeogeographic and mass-balance reconstructions without integrating sedimentary studies with detailed petrographic and provenance analysis.

TECTONIC, EUSTATIC AND CLIMATIC CYCLICITY IN A MIXED CLASTIC-CARBONATE SUCCESION (LOWER EOCENE, SOUTH-CENTRAL PYRENEES, SPAIN)

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Sequence stratigraphy is a powerful tool to predict the nature and timing of surfaces and sedimentary packages from marine to continental successions. It provides insights on the sedimentary response to external forcing (Milankovitch cycles, eustasy variations, climate change and tectonics), contributing to the source-to-Sink comprehension of Earth's dynamics. However, its direct application to mixed (clastic-carbonate) depositional systems can be challenging, as they record the additional interplay of clastic supply vs carbonate production. The resulting facies and stratigraphic architectures of these systems can be very complex to predict, and their recorded autogenic/allogenic signals, particularly in foreland basin settings, are still poorly constrained. Excellent exposures and preservation of different source-to-Sink segments make the south Pyrenean foreland basin ideal to study stratigraphic cyclicity over multiple time scales. In the Ainsa sector of the basin, the Ypresian strata of the Castigaleu Fm. are represented by a shallow-marine clastic-carbonate succession overlain by deep-marine sediments of the Hecho Group. Mapping, sedimentary logging and stratigraphic correlations have been integrated with magnetostratigraphic, biostratigraphic and isotopic data to constrain the development of this mixed succession in response to variable tectonic activity and climatic/eustatic cycles. Facies analysis reveals that the succession is dominated by clastic shelf and delta slope sediments, interbedded with carbonate-rich packages often associated with macrofossil accumulations. Results of integrating facies and physical stratigraphy suggest that at least two major tectonically-controlled sequences can be identified, bounded by regionally-mappable angular unconformities. However, sequences can be still subdivided into different sub-units: retrogradational packages of thin–bedded turbidites bounded by basal unconformities, and overlain by highly progradational mouth bars and distributary channels, (lowstand sets); landward facies shifts with development of extensive retrogradational shelves with carbonate-rich and fossiliferous condensed sections (transgressive sets); distinctive progradational + aggradational (+degradational) trending units with progressive downlap of tidally-influenced fluviodeltaic deposits over the underlying condensed sections (highstand sets). In these latter, several smaller-scale parasequences can recognized, with higher frequency regressive cycles interrupted by minor transgressions and associated flooding surfaces. The succession is abruptly interrupted and eroded by a large-scale unconformity, associated with the formation of a submarine canyon. This sequence stratigraphic interpretation has been integrated with a detailed biostratigraphic study and tested with carbon stable isotopes on bulk rock carbonates. Results, when plotted against published curves, show that higher frequency orbital/climatic signals were potentially recorded, especially towards the upper part of the studied succession. Field evidences demonstrate that tectonic structures were active at the time of deposition of the Castigaleu Fm and controlled facies changes, accommodation and sequence boundary generation at regional scale. However, facies analysis, biostratigraphy and sequence stratigraphic correlations suggest that several smaller-scale eustatic and climatic signals could still be recorded. Two major tectonoeustatic cycles developed during ca. 1.5 Ma, whereas some of the smaller scale cycles observed may fall within Milankovitch eccentricity or even obliquity. Deltaic parasequences, possibly associated with high frequency climatic-orbital cycles, could be possibly recorded due to tectonic quiescence periods and increased shelf accommodation during highstands.

ROCKY COAST EROSION RATES AND COASTAL SEDIMENT BUDGET

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Every rocky coast of the world is eroding at different rate (cliff retreat rates). Erosion is caused by a complex interaction of multiple sea weather factors. While numerous local studies exist and explain erosion processes on specific sites, global studies lack. We started to compile many of those local studies and analyse their results with a global point of view in order to quantify the various parameters influencing erosion rates. We built a database based on literature and national erosion databases. It now contains 80 publications which represents 2500 cliffs studied and more than 3500 erosion rate estimates. A statistical analysis was conducted on this database, indicating cliff lithology is by far the main factor influencing erosion rates. Hard lithologies are eroding at 1cm/y or less, whereas unconsolidated lithologies commonly erode faster than 10cm/yr. This analysis' next step is an evaluation of the flux of eroded material into the littoral sedimentary cell.

LANDSLIDE AND TURBIDITE RECORDS REVEAL A LONG HISTORY OF FREQUENT SEISMIC SHAKING IN EKLUTNA LAKE, ALASKA

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On 27 March 1964, a megathrust earthquake (Mw 9.2) ruptured an 800-km-long segment of the Alaskan-Aleutian Subduction Zone, representing the largest measured earthquake in North America. Lake sediments can record such large earthquakes, since seismic shaking can generate various types of shakinginduced event deposits, such as subaquatic landslides or turbidites. In order to study the sedimentary record of large earthquakes in that region, we studied the sediments of Eklutna Lake, a proglacial lake located in south-central Alaska, using a combination of high-resolution seismic stratigraphy (3.5 kHz), multibeam bathymetry (50 kHz) and sediment cores (~ 15 m).

The seismic profiles and bathymetric maps reveal the presence of 15 sublacustrine landslides caused by the historical 1964 megathrust earthquake. We also identified a series of older landslide deposits in the subsurface, which are all inferred to have been caused by multiple, coeval slope failures, and can thus be attributed to past seismic shaking.

The proximal and distal basins of Eklutna Lake exhibit a different landslide record. We explain this by a different sensitivity of the subaquatic slopes to strong earthquake shaking. Higher sedimentation rates (~1 cm/yr) in the Eklutna proximal basin increase the sensitivity to earthquake-triggered slope failure. Therefore, the proximal basin of Eklutna Lake likely records earthquakes of lower macroseismic intensity.

Sediment cores in each lake basin show a varved “background” sedimentation that is frequently interrupted with earthquake-and (mega) flood-triggered turbidites. We constructed an event stratigraphy of “extreme” events (earthquake or megaflood) by performing a statistical outlier study of varve thickness data. Using this method, we were able to identify turbidites that are more voluminous than “normal” sediment layers and which are thus likely caused by an “extreme” event. Then we ascertained the seismic origin of the turbidites with help of several parameters (e.g. grain size parameters, spatial distribution, spectrophotometric b-values, ...) in order to filter out possible flood-triggered turbidites. The resulting turbidite records represent an independent seismometer of past earthquake events.

A continuous varve chronology together with seven ^{14}C ages allows us to tie our paleoseismic records (landslides and turbidites) to a robust, high-resolution age framework. The paleoseismic records in Eklutna Lake may not only reveal information on large megathrust earthquakes. Due to its inland location, the area can also be prone to shallow earthquakes from surrounding fault systems, e.g. the Castle Mountain Fault. Unraveling the different seismic sources and their characteristic recurrence times will be crucial for understanding the seismic hazard of southern Alaska and in particular the more densely populated city of Anchorage.

STABLE ISOTOPE ANALYSES OF BELEMNITE ROSTRA FROM THE PLIENSBACHIAN-TOARCIAN BOUNDARY: IMPLICATIONS FOR SURFACE WATER CONDITIONS DURING DEPOSITION

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Carbon and oxygen isotope data derived from belemnites are presented from published and new records derived from the Pliensbachian-Toarcian boundary (equivalent to the Margaritatus to Tenuicostatum Zones, immediately prior to the Toarcian oceanic anoxic event). The data are from a number of sites across the Tethys Ocean including Raasay and Dorset, UK, the Lusitanian Basin, Portugal, the Basque-Cantabrian Basin, Spain and the Middle Atlas, Morocco. The belemnite oxygen isotope data presented here shows the most positive values at the lowest latitude site (Morocco) and most negative values at the highest latitude site (Raasay). Given that the opposite trend would be expected from a normal temperature profile (i.e. warm subtropics and cooler temperate regions), suggests that temperature is not the dominant control on belemnite oxygen isotope values. This has implications for Tethys-wide assessments of isotopic temperature change. A possible mechanism to explain the observed trends is that higher latitude waters were less saline during this time interval compared to lower latitudes. Lower salinity waters may have resulted from increased fresh water supply to the basin and may have promoted the development of a haline stratification of the water column.

Reference to the carbon isotope data may well help explain the oxygen isotope trends. The carbon isotope data show the most positive values for Raasay and most negative values from the low latitude Morocco site suggesting spatial heterogeneity in the carbon isotopic composition of dissolved inorganic carbon in the Early Jurassic ocean. However, a large increase in fresh water supply to the basin, would normally result in more negative carbon isotope values at these latitudes, whereas the opposite trend is observed.

To account for both the oxygen and carbon isotope trends it is suggested that the patterns reflect the balance between higher productivity in the higher latitudes and higher salinities at lower latitudes. Whether low-salinity surface waters, triggering stratification of the basin is therefore open to question.

UPLIFT AND CLIMATIC HISTORY ALONG THE NORTHERN PERUVIAN ANDES MARGIN: THE CALIPUY PLATEAU

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Geomorphology, geochemistry and palynology analysis demonstrate that climatic variations retroact on orogenic dynamic, whereas tectonic seems to be the initiating process for mountain building. In the last decades, multidisciplinary studies in the Central Andes attempt to understand processes implied in the Andean relief, especially to understand the formation of one of the largest world-wild plateau, the Altiplano Puna plateau.

Well known two main tectonic stages have contributed in the Andean orogeny since the Late Cretaceous, and were propagated from the Western Cordillera to the Eastern Cordillera and Amazonian basin. However, the relief was at a third of the present elevation before the Oligocene time and probably near sea-level in some regions while the main Andean uplift occurred after 10 Ma. Therefore, associated processes to horizontal shortening were proposed to explain the no-time correlation between the ancient stepwise deformations (horizontal shortening) and late continuous surface uplift (crustal thickening).

The Altiplano plateau, which is by definition a low-relief surface of high elevation, is an endorheic basin located at ~3.8 km a.s.l. at the transborder region between south Peru, Bolivia and north Chile. However others smaller "altiplanos" can be tracked along the western Andean margin. According to Trauerstein et al. (2013), they could still response to the Miocene uplift and seem to be slowly disintegrated thanks to low precipitation rate in the Peruvian Andes compare to the central and southern Chile. In this context,we analyzed one of the most spectacular western Andean escarpment in northern Peru (Trujillo -8°S), where a wide plateau of ~3.5 km high is present.

In this study, we attempt to respond to these main question: What are the process(es) involved in plateau development and surface uplift during the northern Andean orogeny? Do the northern Peruvian "altiplanos" are in a formation or disintegration cycle?

For this purpose, we (1) carry out a crustal balanced cross-section from Middle Eocene through the marine and hinterland plateau landform to define the main actual crustal structures of the Peruvian Andean margin, by the interpretation of offshore 2D seismic sections, field observations and U-Pb zircon dating, (2) to constrain the Cenozoic history thanks to previous and new geochronological and thermochronological data and (3) to compare the orographic dynamic with the past and actual climate, and slab geometry fluctuations.

We show that the offshore regional Middle Eocene unconformity is also found at ~3 km high along the Calipuy Plateau. A fossil forest typical of near-sea-level tropical environment found just above the main unconformity show that a tectonic process had vertically shift this surface of ~4 km after 39 Ma. Compressional structures and thermochronological patterns seem to be consistent with a main west verging thrusts system development post 39 Ma, and that the actual topography reached ~9 Ma ago.

2D NUMERICAL MODEL OF TECTONIC AND SURFACE PROCESSES SINCE MIDDLE EOCENE, NORTHERN PERUVIAN ANDES (6°S-9°S)

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The Cenozoic history of the western Amazon basin was strongly influenced by the Western-Eastern Cordilleras uplift and subsidence of the Sub-Andean Zone. Several paleontological analyses described terrestrial to marine fossils associations in the sedimentary records, allowing to well constrain the paleoenvironments at the interface of the northern Andes and Amazonian basin. Two major marine incursions were defined in the Huallaga basin since the Lower Cretaceous, the Middle to Late Eocene (Upper Pozo Formation) and the Early Miocene to Late Pliocene marine corridors. These inland seaways have been usually interpreted as a consequence of global higher sea level and/or fast subsidence of the Sub-Andean Zone trigger by the Western and then the Eastern Cordilleras loading. However, the lithospheric flexure evolution during the northern Andean orogeny has been never calculated in response to the mass redistribution, tacking to account the orographic effects on erosion. In the aim to validate the orogenic loading and/or sea level rise and/or local climatic causes, we will us the numerical model tAo to calculate the evolution of flexural lithosphere and sea/sediments distribution since the Middle Eocene. The input crustal structure geometries and shortening rates are constrained by thermochronological data associated to crustal balanced-cross section from the Forearc Zone to the SubAndean Zone (6°S-9°S). The resulting 2D model will show if the tectonic deformation is the only mechanism for marine incursion in the western Amazon basin, and will probably specify if the Calipuy Plateau has been an endorheic basin along the western Andean margin.

"NO INFORMATION – GOOD INFORMATION" – VIZ HOW TO MAKE NOMARSKI DIC MICROSCOPY INTO AN ESTIMATE OF INTERSTITIAL CLAYS IN SANDSTONES

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The Nomarski differential interference contrast (DIC) imaging in the reflected light is used in petrographical research to visualize morphology heterogeneities of minerals due to their varying resistance to grinding and polishing. Such imaging is realized by a double-crystal prism, named the Nomarski prism, that splits the entering beam of light, effecting the superposition of laterally shifted wave fronts. Thereby, the Nomarski DIC microscopy creates bright-dark paired shading at the micro-scale induced by differences in the microtopography. Such effect resembles a shadow relief and gives a pseudo threedimensional appearance to the sample.

However, in the case of sandstones, the Nomarski DIC imaging shows the morphology of most minerals to be comparatively homogeneous. Typical features of rock components (e.g. zoning) that are detected in magmatic and metamorphic rocks by the Nomarski DIC microscopy, here are blown by transport, deposition and diagenetic processes. This grey image is found to be very useful in extraction of clay particles from rest components of sandstones because only clays point out heterogeneity as convex and concave areas in this illusory three-dimensional appearance. It applies to clay particles in the form of matrix and grains, what is easy to be distinguished by their shapes. Matrix is dispersed among sandstone grains as irregular areas, whilst clay grains are seen as compact, more or less spherical areas.

The Nomarski DIC equipment in an investigation of siliciclastic rocks contributes not only to a rapid extraction of matrix but also to a quick estimation of their content applying the image analysis. The image analysis works outstandingly satisfactory for relatively homogeneous data obtained from the Nomarski DIC images. Common replacements of minerals by clay minerals derange the automatic image analysis. In those cases, a manual solution is supportive.

The cement present in sandstones, especially microsparite type, appears similar to the clay matrix when observed in plane-and crossed-polarised light. So, the distinction between sparry cement and matrix is questionable with standard petrographic examinations. Because DIC images present all sandstone components with morphology homogeneity except clays, it solves the problem and clearly separates the cement from the rest binders containing clay particles.

In a case study carried out on the Cergowa sandstones, it was expected on the basis of polarising microscopy observations, that the three images would represent arenites with < 15% matrix content and the three wackes with > 15% matrix content. However, DIC images analysed with image analysis have shown that only one sample represents wacke and the content of matrix in sandstones is often overestimated in polarised light images because of an unclear separation between cement and matrix what causes an invalid classification of rocks. The proper extraction of the matrix content in sandstones is important for the hydrocarbon volume and deliverability estimates.

HETEROZOAN CARBONATE DEPOSITION IN A SUBMARINE CANYON CREATED BY A SUBMARINE LANDSLIDE (LATE MIOCENE, ALHAMA DE ALMERÍA, SE SPAIN)

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A medium-scale submarine landslide influenced the slope sedimentation at the western margin of the Almería-Níjar Basin (SE Spain) during the late Tortonian-early Messinian (late Miocene). The rotation of collapsed rocks around the main axis of the landslide created a canyon-like depression along the southern margin of the failed structure. This depression acted as a depocentre in the lower slope for the accumulation of post-landslide deposits, as it funnelled the sediment gravity flows that were generated upslope, promoting local thick accumulations of sediments. The canyon infilling is a roughly pyramidal sediment body of triangular section about 4500 m long and up to 1600 m wide. The deposits consist of heterozoan carbonate components mixed with varying amounts of terrigenous grains, including breccias and conglomerates, grouped in three main redeposited facies interpreted as sediment gravity flow deposits: clast-to matrix-supported breccias, rudstones with terrigenous clasts and bioclastic grainstones alternating with silty marls and silty sandstones with dispersed clasts. In the distal part of the canyon, sediment gravity flow deposits occur mainly as scour-and-fill structures within concave-plane bedsets of limited lateral continuity separated by thick intervals of fine-grained sediment, suggesting that they accumulated in ephemeral submarine channels of small dimensions within the canyon-shaped depression. The mixing of coarse-grained bioclastic flows with angular to subangular terrigenous clasts in the lower part of the canyon infilling suggests the erosion and reworking of the canyon margins close to the slide scarp. Upwards, the detrital sediment is dominated by bioclastic carbonates accumulated in large decametre-thick channelized stacked bodies separated by erosive concave-up bases. This example of canyon formation highlights the importance of slope failures in controlling the sediment routing and distribution in carbonate slope systems.

SPATIAL SELF-ORGANIZATION IN REEFAL CARBONATES – SUBOPTIMAL CONDITIONS YIELD SPECTACULAR PATTERNS

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Spatial self-organization, the process where coherent spatial patterns emerge through internal interactions, is widely observed in modern natural systems. Predictably, remote sensing has risen to the fore as a means of studying this phenomenon. Compelling examples of self-organization range from ripple and dune formation in aquatic and terrestrial systems to formation of patterned vegetation in arid regions. Despite this wide range of contemporary cases, the concept of self-organization and its potential effects on geological patterns have not yet been widely discussed by the geological community, especially in carbonate depositional systems.

Common atop both carbonate shelves and isolated platforms, the most striking example of coherent patterning for biotic reefs is that of cellular networks of reef ridges, informally called "mesh" or "reticulate" reefs. This morphology has been extensively reported in the modern ocean and also identified in the Cenozoic, Mesozoic, and as far back as the Paleozoic. Spanning the tenure of a wide variety of reef architects, there are two reasonable explanations for the formation of reticular reef morphology. It was originally explained as being guided by antecedent seafloor topography that the reef-formers simply veneered and accentuated. In this argument, the preexisting patterning was traditionally attributed to karstan excellent example of an inherited pattern and the opposite of self-organized. Recent reexamination of reef morphology indicates, though, that this patterning may have a biological origin and emerges through self-organization.

It is a long held premise that self-organized patterns only evolve in systems out of equilibrium and where competition between various tendencies exist at different length scales. While such a confluence of scales is characteristic of all evolving growth processes, there is compelling evidence that hostile environmental conditions promote emergent patterning of reefs. For instance, reticular buildups are rarely observed on carbonate platforms that are well flushed with normal marine waters, but commonly occur in restricted platform interiors, such as atolls with coherent rims. To explain how self-emergent patterning can biologically arise in reefal carbonates, it is essential to recognize their inherent patchiness, the relationship between a reef-building organism and the water mass in which it is immersed, to understand the role of turbulence and to accept that sediment is nothing but bad news for reef builders. I propose that feedbacks develop at short (colony) length scales associated with smothering and overcrowding operate in disequilibrium to those associated with access to clean ocean waters for feeding and removal of harmful metabolites, operating at long (reef) length scales. The disequilibrium is exacerbated under restricted conditions when the reef strives to adopt a growth form that maximizes access to well-ventilated waters, but minimizes overcrowding at the colony scale. These competing processes trigger the adoption of complex emergent patterns. An appreciation of self-organized processes in carbonate depositional systems opens a new class of tantalizing complex models which exhibit a much richer spectrum of patterns than offered by more traditional approaches to understanding the production and accumulation of carbonate sediments.

THE NUMERICAL SIMULATION OF CLASTIC DIAGENESIS BASED ON DEPOSITION PROCESS AND RESERVOIR PREDICTION: AN EXAMPLE FROM THE PALEOGENE LAKE SEDIMENT SANDSTONE IN CHINA

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As new exploration domain for oil and gas, reservoirs with low porosity and low permeability have become a hotspot in recent years. With the improvement of technology, low porosity and low permeability reservoirs are commonly found in most sedimentary basins, which makes this kind of reservoir more and more meaningful. The success of reservoir prediction depends mainly on finding reservoirs with sufficient porosity and permeability. Reservoirs with low porosity and low permeability are characterized by diagenesis diversity, strong heterogeneity and complex fractures. Thus there is a great challenge to identify position of favorable reservoirs with low porosity and low permeability by traditional exploration means.

Sedimentary facies and diagenesis are the main factors controlling reservoirs porosity evolution, and sedimentary facies controls porosity evolution at shallow burial depth while diagenesis affects pore evolution at deep burial depth. Diagenesis is a necessary process for the development and formation of all reservoirs, which ultimately determines the reservoir physical property. This is particularly true for reservoir with low porosity and low permeability.

Numerical simulation of diagenesis process is to select diagenetic parameters and simulate its temporal and spatial distribution, and then to evaluate favorable reservoir by simplified model according to actual needs. Our research was to study reservoirs with low porosity and low permeability formation mechanism in burial process which is the basic principle of science. It can provide a good way for reservoir prediction in high diagenetic stage.

The porosity and permeability have close relation with the original composition and structure, which is controlled by sedimentary facies. It is found that sedimentation is a basic factor for generating low permeability reservoirs, and the strong compaction and cementation are the key factors for forming low porosity and low permeability reservoirs. The effect of compaction, cementation and dissolution during diagenesis has been discussed by different scholars.

At present, the numerical simulation methods fall into two major categories. The first category is based on physical or chemical model, which use single factor model to simulate the effect of diagenesis on pores while the other one only considers the comprehensive results of diagenesis on pores, but not caring about concrete diagenesis. In our study we firstly simulate the effect of different diagenesis on pores in burial history, and then a synthetic equation model was established, which can be used to compute the porosity of clastic reservoirs, particularly on reservoirs with low porosity and low permeability.

DISTINCTION BETWEEN FORCED REGRESSIVE AND HIGHSTAND/LOWSTAND WEDGES IN HANJIANG FORMATION OF PEARL RIVER MOUTH BASIN, NORTHERN SOUTH CHINA SEA

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Based on the stacking pattern of stata and their component facies revealed by a large amount of 3D seismic data set as well as well data, this study presents the typical recognition to distinguish falling stage systems tract (FSST) from highstand/lowstand systems tract (HST/TST) in Hanjiang Formation of Pearl River Mouth Basin, northern South China Sea. Highstand prograding wedge mainly developed in the shelf area, with shoreface angle less than 0.5°, and evolved into the condensed section basinward. While forced regressive and lowstand prograding wedges developed in the shelf edge and slope area, presenting high angle (1°~3°) progradation in dip orientation. Lowstand prograding wedge was characterized by sigmate progradational reflection configuration, with thin and continuous topset lying on FSST, which suggests relative sea level rising during LST stage. Forced regressive wedge was composed of parasequences that tended to be wave influenced, and lowstand prograding wedge was characterized by assemblage of river influenced facies. During forced regressive period, shoreline was forced to move seaward uniformly, so that leagues of shelf edge delta/coarse coastal deposits developed and longshore deposits elongated along SW-NE near shelf break. Shelf break was more accentuated after FSST with sediments concentrating mainly in shelf break and upper slope area. Shoreline did not uniformly migrate seaward in LST stage, and Shelf edge delta developed in western margin where the sedimentary supply was high and longshore activity weakened. Sequence architecture in deepwater area also presents complicated distribution features. The sandy deepwater fan preferentially developed in LST due to stronger deltaic progradation and higher slope gradient in the western margin.

SEQUENCE AND SEDIMENTARY CHARACTERISTICS OF ALLUVIAL DEPOSITIONAL SYSTEM AND ITS CONTROLLING EFFECT ON THE HYDROCARBON ACCUMULATION: A CASE STUDY OF TRIASSIC IN BAIKOUQUAN AREA, JUNGGAR BASIN, NORTHWEST CHINA

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Alluvial depositional system developed at the conversion area of mountain to basin. It directly linked the source region (provenance) and sink area. The sequence and sedimentary characteristics of alluvial depositional system indicates the tectonic activity and rock characteristics of source region. It also reflects the subsidence rate and change of accommodation of sink area. Based on the high-resolution development seismic data, outcrop, abundant wells data and coring analysis data, the sequence stratigraphic of the Triassic in the Baikouquan area was established. The facies types, distribution and controlling factors of alluvial depositional system were analyzed under the sequence stratigraphic framework. Moreover, the characteristics of hydrocarbon accumulation under the control of sequence and depositional system was discussed. The research shows that: (1) The Triassic in the Baikouquan area is a whole second-order sequence, which undergoes the period change of lake rises and fall. According to the difference of its internal sedimentary characteristics and its indication of the lake level change, the second-order sequence can be further divided into three third-order sequence: Baikouquan formation and lower Karamay formation (except S6 sandy group) mainly developed lowstand system tract and formed the lower third-order sequence (TSQ1); S6 sandy group and upper Karamay formation mainly developed lowstand system tract and highstand system tract, they composed the middle third-order sequence (TSQ2); Baijiantan formation formed the upper thirdorder sequence (TSQ3), which is mainly developed transgressive system tract and highstand system tract. (2) Alluvial fan, fan delta and braided river delta are the main sedimentary facies of the Triassic alluvial depositional system in Baikouquan area. The lower third-order sequence (TSQ1) developed in the stage of low lake level and formed extensive superimposed transgressive alluvial fans. With the rise of lake level, the middle third-order sequence (TSQ2) developed fan delta. When it comes to the early stage of upper thirdorder sequence (TSQ3), the lake rose rapidly and reached the maximum level, it developed shore to shallow lacustrine. The lake decreased in the later stage of TSQ3 and developed braided river delta. (3) The sequence and sedimentary characteristics of the Triassic in Baikouquan area have a good coupling relationship with the hydrocarbon accumulation. At the bottom of the second-order sequence (TSQ1) developed near provenance conglomerate reservoir with large thickness. The reservoir close to the oil-migrating faults which is open during the early stage and blocked in the latter stage, thus the reservoir has better hydrocarbon migration condition in the early stage and barrier condition in the latter stage, all above those conditions contribute to the formation of tectonic-lithologic reservoir with high reserves abundance. At the middle and upper of the second-order sequence (TSQ2 and TSQ3) developed large scale fan delta and braided river delta which are developed abundant distributary channels with high quality. The difference of reservoir properties caused by the different depositional environment apt to form properties barrier. Those conditions are benefit for the formation of large scale lithologic reservoir.

THE MID PALEOCENE PARADOX: NEW STRATIGRAPHIC AND ENVIRONMENTAL CONSTRAINTS FROM THE SELANDIAN OF THE NORTHERN PYRENEES

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Through the RGF program and Orogen project, sedimentologic and stratigraphic studies have been conducted since 2016 in the North Pyrenean Foreland Basin (NPFB) in order to i) refine the stratigraphy in the Corbières Garumnian facies, particularly those of the Paleocene-earliest Eocene, ii) correlate them to the marine realm to the west with a higher resolution, and iii) better delineate the paleogeographic and paleoclimatic reconstructions of the foreland basin during an interval reputed for its tectonic quiescence. To reach those objectives the main methods involved are $\delta^{13}C$ chemostratigraphy, pollen, spore and dinocysts palynology, as well as foraminifera biostratigraphy. A $\delta^{13}C$ curve has been first obtained for the whole Paleocene and earliest Eocene of the Lairière (Aude) succession, which consists in mainly terrestrial sediments and subordinate coastal and shallow marine units. Selandian units with depositional environments varying rapidly (alluvial, fluvial channel, coastal, shallow marine and lacustrine) are identified thanks to a remarkable $\delta^{13}C$ double CIE: first positive in the shallow marine sediments, followed by a very negative in the lacustrine beds, with a sharp decrease of about 8.5 ‰ in between. This $\delta^{13}C$ double CIE is correlated to a similar one in the upper part of the Selandian in the Zumaia marine reference section (Spain), though with a much lower amplitude (3.5 ‰) in between. Peyrolles (Aude), a section south of Lairière, exhibits a Selandian unit deposited in coastal to shallow marine conditions, on top of the Vitrollian terrestrial succession.

The Selandian interval is much thicker (41 m) than in Lairière (6 m). In both locations these sedimentary units were previously attributed to the "Early Thanetian", are now dated as Selandian thanks to $\delta^{13}C$ and foraminifera data, and contain remarkable sporopollinic assemblages, homogeneous between the two sections, rich and diversified. This microflora is very similar to those of the Selandian 'Sables Inférieurs' of the Pyrénées Atlantiques and of the Menat Maar in the Massif Central. It suggests a subtropical to tropical climate with contrasted seasons and/or humid and drier environments coexisting in the landscapes. Palynofacies shows charcoals and resinite particles, as well as a less diversified microflora arising from the hinterland forests in a few fluvial samples. Our new data have implications regarding the Paleocene evolution in the Pyrenean domain s.l. Firstly Selandian coastal and terrestrial units are now recognized in the Corbières (Aude) and correlated with the Selandian of the Pyrénées Atlantiques and Zumaia, in marine turbiditic units, whereas this stage is not recorded in the carbonate platforms in Spain nor in the Aquitaine Basin, a hiatus being instead reported in the literature. This contrasted setting and the rapid thickness and facies variations in the Corbières could suggest variation in tectonic activity in the NPFB and adjacent domains. The Selandian should also now be sought in other Corbières and southern Pyrenees sections. Secondly, the $\delta^{13}C$ evolution in the Pyrenean Selandian is per se an anomaly, when compared to the published Paleocene $\delta^{13}C_{carb}$ curves and remains to be explained: probable regional processes affecting the organic matter or geodynamic triggers could be invoked.

CARBONATE PRECIPITATION IN MICROBIAL MATS DEVELOPED IN A SILICICLASTIC COASTAL ENVIRONMENT OF N PATAGONIA (ARGENTINA)

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Microbial mats can alter the microenvironment where they live, changing the geochemical conditions and favoring the precipitation of autigenic minerals such as calcium carbonate. The metabolic processes of the microbial community, together with the production of EPS and extrinsic factors, such as environmental conditions, are decisive for mineral precipitation. Although carbonate precipitation induced/influenced by microbial communites has been extensively studied in carbonate environments and laboratory cultures, it has been scarcely reported in siliciclastic environments. This study documents the precipitation of continuous, well-defined carbonate laminae within microbial mats from a siliciclastic environment. Paso Seco, located in northern Patagonia (Argentina), is a supratidal coastal plain (~2.5 x 0.3 km) developed in a lowlying area among eolian dunes, which constitutes the remnant of an old tidal channel that was disconnected from daily connection with the sea by the formation of a sand spit at its mouth. After the spit formation, the exposed bottom of the channel was colonized by extensive thick microbial mats. Nowadays the study area is flooded during storm events and presents an annual variation of the water table of ~1 m (up to 70 cm above the sediment surface during storms and up to 30 cm below the surface during summer) and high solar radiation in summer. 20 cm-deep sedimentary cores extracted from the plain show that the sediments consist of an alternation of up to 4 cm-thick sand layers and biolaminites. The petrographic study of the biolaminites allowed the identification of characteristic, repetitive, up to 2 mm-thick sequences composed of four different types of laminae. Each sequence begins with a silt and fine to medium-grained sand lamina that shows a sharp lower contact. The basal lamina is overlain by an up to 400 µm-thick lamina of clay to fine-grained silt, amorphous organic matter, diatoms, and cyanobacteria sheaths. This layer displays abundant, generally subvertical, cyanobacteria filament molds that continue into the overlying lamina, which consists in a 100-200 µm-thick layer of dense micritic calcite. Finally, the uppermost 75-100 µm-thick lamina is composed of amorphous organic matter, diatoms and cyanobacteria sheaths, showing a horizontal laminated texture. These sequences might record the changing conditions achieved in the study area. The basal silty-sandy lamina is probably the result of a sudden sediment input during an episode of seawater income. During winter, the plain remains flooded for most of the time and phototrophic organisms may generate the abundant organic matter that overlies the silty-sandy lamina. The cyanobacteria filaments are subvertically oriented in the lower part of the mat and lie horizontal on the surface. During summer, water evaporation is intense and carbonate saturation is achieved, allowing the precipitation of calcite in the boundary between the laminae with vertically and horizontally oriented filaments. Therefore, the carbonate precipitation in the studied microbial mats developed in a siliciclastic environment is the result of the combination of microbial processes plus the environmental factors that allow carbonate saturation to be reached.

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EVAPORITE DEPOSITS AND INTRACLASTIC BRECCIAS IN THE REMNANT OF THE RHEIC OCEAN DURING THE MID-CARBONIFEROUS BOUNDARY (BARCALIENTE FM, CANTABRIAN ZONE, NW SPAIN)

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The Cantabrian Zone of NW Spain displays excellent exposures of the Variscan marine foreland basin that developed during the collision between Gondwana and Laurentia in Carboniferous times. This basin represented the narrowing remnant of the Rheic Ocean, a subequatorial seaway connecting the Panthalassa and Palaeotethys Oceans, which subsequently became a marginal sea, isolated from Panthalassa and only connected to Paleotethys. Up to 350 m of pelagic-hemipelagic, laterally-continuous, dark, laminated calci-mudstone sediments accumulated in this basin during late Serpukhovian-earlyBashkirian times (Barcaliente Fm), without any adjacent coeval, shallow-water carbonate platform described up to date. Contrasting with the homogeneity of most of the Barcaliente Fm, the uppermost part of this unit includes a decametrethick stratal package with abundant calcite and quartz pseudomorphs after gypsum. The pseudomorphs are millimetre-sized, and show mainly monoclinic equant prismatic habits. They occur as isolated crystals or coalesce into laterally-continuous laminae, and the calci-mudstone matrix is deformed around them. These features suggest that the gypsum grew displacively within the carbonate matrix in the sediment-water interphase or slightly underneath it. The pseudomorphs are more abundant, show smaller sizes, and form more continuous laminae towards the top of the Barcaliente Fm, suggesting an increase in salinity with time. The presence of evaporites in pelagic-hemipelagic sediments along the entire Cantabrian Zone suggests that an evaporitic basin could have been developed in the foreland basin around the Serpukhovian-Bashkirian boundary, as a consequence of tectonically-induced isolation and the mid-Carboniferous sea-level lowstand, recognized worldwide. Deposition of intrasediment evaporites in pelagic areas of the basin indicates that the whole basin was probably holomictic and saturated with gypsum, and points to an important sea-level fall. Similar laminated calci-mudstones with pseudomorphs after gypsum are also present in coeval sediments from the Pyrenees, 400 km away from the Cantabrian Zone, which indicates that the evaporite sedimentation extended over wide areas of the Rheic Ocean remnant. The evaporite-bearing stratal package is overlain by a decametre-thick clast-supported intraclastic breccia (Porma Breccia). This breccia shows an irregular, but predominantly-flat lower contact, and a very irregular upper contact with vertical chimneys that cross-cut and deform the overlying carbonate beds (Señares Mb). The lower part of the breccia is mainly composed of millimetre to centimetre-sized fragments of calci-mudstone with pseudomorphs after gypsum (identical to those in the underlying strata) in a groundmass of micrite, and pseudosparite and quartz (which contain anhydrite inclusions and lenticular pseudomorph habits). The upper part of the breccia is composed of up to metre-sized fragments of limestones, whose microfacies are identical to the overlying strata of the Señares Mb, with a predominantly marly matrix. Some of these fragments lie subvertically and show ductile deformation. These features suggest that the breccia could have been triggered by the flow of the uppermost part of the evaporitic unit, accompanied by subsequent evaporite dissolution and collapse of the interlayered and overlying carbonate beds. Brecciation took place in the subsurface, prior to the complete lithification of the uppermost strata of the Señares Mb.

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CELESTITE FORMATION AS THE RECORD OF THE INTERACTION OF SR-BEARING CARBONATE DEPOSITS AND HYDROCARBON FLUIDS IN THE BARCALIENTE FM (CARBONIFEROUS, N SPAIN)

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Celestite ($SrSO_4$) is a common but relatively minor diagenetic component in many marine carbonate rocks. Although several mechanisms have been proposed for celestite formation, the origin of numerous celestite deposits remains enigmatic. In this work, the origin of the celestites present in the carbonate deposits of the Barcaliente Fm (uppermost Mississippian-lowermost Pennsylvanian, Cantabrian Zone) is interpreted. The Barcaliente Fm is a 50-450 m thick, pelagic–hemipelagic carbonate unit recognized along the entire Cantabrian Zone. This unit is mainly composed of slightly burrowed, homogeneous to slightly laminated microsparites (facies A), which are interbedded with laminated calci-mudstones (facies B), laminated marls (facies M), and cm-thick silty to sandy calcimudstone beds (facies C). Facies Band M generated liquid hydrocarbons. Celestite minerals are mainly recognized in the lower part of the Barcaliente Fm, both as dispersed replacive minerals and filling fractures (along with calcite, fluorite, and occasionally pyrite). Replacive celestites are submillimetre in size, and they occur mostly in previously compacted laminae of facies B and C, and less commonly along bedding planes of facies A. Replacive celestites show euhedral prismatic habits, commonly forming concentrically-arranged polycrystalline aggregates, and contain abundant symmetrically-arranged microspar inclusions. The presence of celestites replacing compacted deposits (preferentially in more permeable layers or discontinuities) and filling fractures suggests that celestite precipitation was related with fluids passing through the Barcaliente Fm during burial diagenesis. The relatively low solubility of celestite limits the transport of Sr^{2+} and SO_4^{2-} to the site of precipitation in the same diagenetic fluid, and points to different origins for these two components. Thus, in order to determine the origin of the Sr^{2+} and the SO_4^{2-}, isotopic compositions of the celestites have been analysed. $^{87}Sr/^{86}Sr$ composition of the celestites ranges from 0.708082 to 0.708272, which match perfectly with the $^{87}Sr/^{86}Sr$ values of the carbonates in which the celestites were precipitated, suggesting that the Sr^{2+} of the celestites was probably released into solution by the interaction of the adjacent carbonate with the fluid. The most probable sulphate source was connate waters. δ34S composition of the celestites ranges from 17.6‰ V-SMOW to 36.1‰ V-SMOW, which is much higher than that of mid-Carboniferous marine sulphates (~15-19‰ V-SMOW). However, postdepositional alteration of sulphate isotopic composition is possible if redox reactions occur. Considering that the association of dissolved sulphate (DS) and hydrocarbons is thermodynamically unstable, the DS of the Barcaliente Fm could have been thermochemically reduced by the hydrocarbons that migrated through the unit. Thermochemical sulphate reduction (TSR) causes preferential partitioning of ^{32}S into sulphide, and drives the residual DS toward higher $\delta^{34}S$ values. Considering that the kinetic S isotope fractionation during TSR at the temperature reached by the Barcaliente Fm (~100°C) would be ~20‰, TSR could easily account for the shift to the measured $\delta^{34}S$ of the celestites.

These data suggest that the celestites of the Barcaliente Fm resulted from the interaction between Sr-bearing carbonates, connate waters containing sulphate and migrating fluids that transported hydrocarbons.

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SHELF-CANYON CONNECTIONS ON THE MARANHÃO MARGIN, NORTH-EAST BRAZIL, OFFSHORE SÃO LUÍS: EARLY RESULTS FROM THE SHEOPS CRUISE (MAY-JUNE 2017)

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Continental shelves constitute a key environment to better constrain sedimentary supplies from continental sources (e.g rivers) to offshore deposits (fans, canyon levees). As transitional interfaces between oceans and continents, they are able to record interactions between climatic variability, sea level fluctuations and tectonic events. The north-eastern Brazilian margin, from São Luis estuary, along São Marcos Bay and Arraial Bay, is a large shelf, up to 130 km wide. Away from the influence of the Amazon river, this shelf portion constitutes an ideal area to observe different transfer pathways from "source to sink", especially the shelf-canyons connections. Indeed, data acquired during the Magic cruise (June 2012), conducted by an Ifremer/Petrobras team in close collaborations with University of Brasília, Univ. of Lisboa and Univ. of Bretagne Occidentale, show the continental slope largely incised by numerous submarine canyons. In order to complete these first data sets and to understand the architecture of the quaternary deposits on the shelf itself, the SHEOPS cruise was programmed (May & June 2017) by the french UMS Flotte, in collaborations with Rio de Janeiro State University (UERJ) and Fluminense Federal University (UFF), in the framework of the Amazone Blue & Green project (Franco-European-Brazilian Building Sciences program https://marinebrazil.sciencesconf.org/). The first results of SHEOPS cruise reveal a large field of NW-SE oriented dunes, covering a surface of around 40 x 50 miles from 30 to 55 m of water depths. These giant dunes vary from 3 to 6 m high for lengths up to 7 km. They are more widely spaced approaching 60 m of water depth and disappear completely after 70 m of water depth, close to the slope break. The dunes system seems to be related to the main swell direction, coming from North-East. The North-West limit of the dunes field could correspond to the change of the shelf edge direction (N145 to N120) which may interact and diffract the swell energy. Further offshore, a long belt of bypass occurs from 70 to 100 m of water depths, with a (carbonate) platform with some sparse rock or reef outcrops. Finally, canyon heads dissect the slope, starting around 100 m of water depth, on the edge of the shelf, without any further connections with the inner shelf. These canyon heads show numerous spoon shape scours, abruptly deepening up to 180 m of water depth, that were likely created by retrogressive processes. These first results tend to show that there is no more direct connections from the continent to the continental slope, and the sand stored on the shelf does not reach the canyons' heads nor interfluves (no sand in core MGC06), and thus will not be transferred to the continental slope. Further investigations are needed to understand if any paleo-valleys have existed and have been eroded during the last sea-level rise and highstand or if this portion of the margin has always functioned as a by-passing zone.

COLD-WATER CORAL MOUNDS OFF BRAZIL REVISITED: AGE AND ENVIRONMENTAL CONSTRAINTS ON GROWTH AND DEMISE

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In contrast to their tropical counterparts, cold-water corals (CWC) have a cosmopolitan distribution in all worlds oceans and can build large reefs or mound like structures. These mounds have intensively been studied in the last decades on the European Continental margin. Here, mound growth and demise has been associated to global climatic and oceanographic dynamics. Only a few studies exist that focused on CWC mounds on the Brazilian margin. Here, a different and unique growth pattern has been shown. In particular, CWC growth of the late Pleistocene occurred in intervals of rapid climatic change such as Heinrich I and II as well as the Younger Dryas. Until now, no clear explanation has been found to fully capture this phenomenon of the west South Atlantic. We have revisited the CWC mounds on the Brazilian margin during research cruise M125 with RV Meteor. Our preliminary results are based on CT-Scans, taxonomic descriptions and ^{230}Th/U age determinations. Our taxonomic descriptions suggest that mounds off Brazil were built by CWCs such as Solenosmilia variabilis and Madrepora oculata. as no Lophelia pertusa, the dominant reef building species, has been found so far. Moreover, our new age constraints will further shed light into the debate on what the controlling parameters of the Brazilian CWC mounds are and if these are comparable to those of the North Atlantic.

STORM EFFECTS ON THE DECADAL SHORELINE DYNAMICS OF A SANDY COAST: THE EXAMPLE OF THE GOULVEN BAY (BRITTANY, FRANCE)

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Recurrent storm events cause erosion and important damages on the northwest coasts of France. In a context of a global mean sea level rise and climate change, this risk of erosion is expected to increase in the next decades. There is a need to better understand the impact of storm activity on the coast.

This study aims (1) to quantify the spatial shoreline mobility of the Goulven Bay (Brittany, France) over the past 39 years, (2) to identify the storm events and extract their characteristics to evaluate their impact on the coast. The shoreline mobility is estimated from a set of aerial images of the French National Geographic Institute (IGN). These images, acquired during 12 campaigns between 1977 and 2016, were orthorectified, included in a GIS, and georeferenced. The shorelines were digitized in the GIS for each campaign. The net shoreline mobility between two timelines was quantified with a 50-m step using the Digital Shoreline Analysis System (DSAS) software. The temporal distribution of the storm events was reconstructed from the Brignogan weather station measurements (Météo-France), climate reanalysis (ERA-Interim and ERA-20C from ECMWF) and the DREAL storm inventory of Brittany. Wind velocity, wind direction, significant wave height, mean sea level pressure, predicted tide, tide level form the Roscoff tide gauge and surge calculations were then used to characterize the different storm events.

Our results show that significant shoreline displacements have occurred over the past 39 years, with average velocities from -1 m.yr^{-1} to +4 m.yr^{-1} and high interannual and spatial variabilities. 163 storms of variable duration, frequency and intensity have been detected with a wind velocity threshold of 22 m/s. The 1989-1990 winter, which displays 5 storms of 1 to 11 hours duration combined to important depressions (980-990 hPa), high waves (9-10 m) and spring-tides, is linked to a significant shoreline evolution: -10 m.yr^{-1} between the 1987 and 1990 aerial images in the center of the bay against +15 m.yr^{-1} at the west (Penn ar C'hleuz spit). The comparable energetic winter of 2013-2014 is related to a strong erosion along the entire coast. At some periods, the beach exhibits a certain stability linked to minor average storm intensity (1991-1992) but also a large accretion of the Penn ar C'hleuz spit when storm intensity and recurrence are lower (2004-2005).

Shoreline evolution is strongly influenced by the recurrence and intensity of storm events. Erosion of the bay is generally connected with high wave height and wind velocity but accretion of the Penn ar C'hleuz spit occurred in the same period, related to the strong influence of the longshore drift in this bay.

RECOGNITION OF TECTONIC SETTINGS IN COLLISIONAL SYSTEMS USING BULK-ROCK GEOCHEMISTRY: AN EXAMPLE FROM THE ACCRETIONARY WEDGE OF THE WESTERN ALPS

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The present study describes a first correlation of the detrital composition of the flysch accumulations in the Western Alps with the successive stages ofthe Alpine Orogen using bulk-rock geochemistry. The aim is to better constrain the evolution of the Alps from detrital sediments.

During orogens, the palaeogeography greatly changes with the crustal deformation of the upper plate and the building-up of the sedimentary accretionary prism. They respectively lead to the exhumation of deeply buried units forming the axial belt and to the stacking of sedimentary covers on the subducting plate. These modifications are recorded in the detrital sediments (i.e. flyschs) deposited along the trench and then accreted to the accretionary wedge. The analysis of the mineralogical composition allows to reconstruct the evolution of the sedimentary flux and to constrain the deformation of the orogenic wedge.

In the Western Alps, flyschs accumulations are widespread in the Chablais and Swiss Prealps for the Western Alps. These reliefs comprise a stack of several cover nappes detached from their basement during the subduction of the Alpine Tethys, following a thin-skinned, in-sequence thrusting. Flysch deposition in the successive palaeogeographic domains, from the southern to the northern margin, is useful to monitor the sedimentary flux from the onset of the Alpine subduction. The former flysch accumulations include: (1) the flyschs of the Upper Prealps nappe (Piemont Ocean, Lower Cretaceous to Paleocene), (2) the Brèche and Médiane flyschs of the Briançonnais domain (Paleocene to Middle Eocene) and (3) the Voirons-Wägital flyschsnappe complex (Valais domain, Middle Eocene to Early Oligocene?). The Taveyannaz and Val d'Illiez sandstones (4) (Early to Middle Oligocene), corresponding of the initial detrital sedimentation in the North Alpine Foreland basin, is also included.

Framework composition and heavy mineral analysis have been undertaken several decades ago. They highlighted (a) initial Cr-Spinel input from the oceanic crust which is progressively replaced by (b) metamorphic input (garnet from the rising axial belt). Finally (c) the last depositional stage includes hornblende and pyroxene of fresh volcanic input from the Oligocene magmatic event. The ongoing process consists in the analysis of major and trace elements from the studied units (1-4). Most of the detrital composition is characterised by a high content of (ultra-)stable grains. The use of the bulk-rock geochemistry enables to overcome the bias of weathering and reworking and to better discriminate the successive tectonic settings (a-c).

In addition, samples were collected in various grain-size, from pebbly sandstone to fine sandstone, to assess the influence of the latter in the results and their implications will be discuss in the framework of provenance analysis.

SIGNIFICANCE OF DOLOMITE CEMENT FORMATION IN THE FLUVIAL-LACUSTRINE RESERVOIR FROM THE ZOOVCH OVOO URANIUM DEPOSIT, MONGOLIA

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The Zoovch Ovoo uranium deposit is hosted in the Sainshand Formation, an Upper Cretaceous siliciclastic reservoir, upper part of the post rift infilling of the Mesozoic East Gobi Basin (Mongolia). This Sainshand Formation corresponds to an alternating of unconsolidated medium-grained sandy intervals and clay layers deposited in fluvial-lacustrine settings. The uranium deposit is confined within a 60-80 m thick siliciclastic sequence inside roll-front systems. In our sampling, the ore is expressed under four forms: (i) U-rich organic matter without any distinguishable U-phase or sulphide; (ii) UO_2 associated to pyrite; (iii) a continuous compositional series from UO_2 to $USiO_4$ associated to/replacing pyrite; and (iv) U-phases associated to organic matter within altered feldspar. This siliciclastic reservoir could be cemented by carbonate occurrences. Although the regional area is calcite-dominated, the roll-front is characterized by dominant dolomite with different textures. Hence, the dolomite fabrics of Zoovch Ovoo were studied in detail, in order to uncover their origin and diagenetic history. The dolomite was investigated by 1) petrographic observations of ordinary microscopy, complemented by cathodoluminescence as well as SEM images 2) crystal-chemistry data obtained with SEM-EDS, EMPA, XRD and LA-ICPMS. There are large variations among the different dolomite fabrics with respect to the size and geometry of the crystals, which can be classified under four types indicating possible successive recrystallization episodes, starting with: (i) microcrystalline, (ii) euhedral, (iii) subhedral and (iv) anhedral. Despite the petrographic contrasts, the majority of the carbonate cemented sandstones are chemically identical and show little variation in major elements. Their stoichiometry is very close to dolomite, with slight variations concerning Ca and exchanges of Mg by Fe and/or Mn, mostly occurring as dolomite crystal zonations. The most significant variations appear for Rare Earth Elements (REE) and to some extent for minor elements (Sr, Mn). Thus, the microcrystalline type shows REE concentrations ranging between 130 to 1800 times that of chondrites with relative enrichment of the light REE. The euhedral type contains REE concentrations 10 times lower than the microcrystalline; the subhedral 30 times lower and the anhedral 100 times lower, while relatively enriched in heavy REE. Regarding the stable isotopes, $\delta^{18}O$ PDB and $\delta^{13}C$ PDB values range between -9.48‰ to -11.79‰ and -5.59‰ to -7.71‰, respectively for the dolomite cemented sandstones and between -11.68‰ to -14.61‰ and -5.74‰ to -8.64‰ for the calcite cemented (from Zuunbayan sub-basin used for comparison). The lighter $\delta^{18}O$ values for calcite suggest that the origin of the water is meteoric, while the slightly heavier values for dolomite suggest interaction with the aquifer. All data taken into consideration, it is proposed that the various dolomite types reflect various degrees of interactions with aquifer circulating fluids. It is proposed that the endorheic basin situation of the Zoovch Ovoo deposit combined to climate control lead to a limited water budget. As a consequence, formation and circulation of brines eventually rich in dissolved organic matter favoured dolomite cement formation. According to currently available data, uranium bearing fluids might be contemporary only to the anhedral dolomite (Type IV).

SEDIMENTARY HISTORY OF LAKE ACIGÖL (SW TURKEY): POTENTIAL FOR A NEW LONG-TERM QUATERNARY PALAEOCLIMATIC RECORD IN ANATOLIA

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Lake Acigöl in SW Turkey occupies a vast tectonic extensional basin. The modern shallow, but permanent lake is currently industrially exploited for Na-enriched minerals through evaporation ponds. A 601 m long core was extracted from the basin in 2009 and dated to cover at least the last 1.7 Ma, with a base potentially reaching more than 2 Ma (dating through magnetostratigraphy and tephra layer).

This sequence, potentially the longest continuous continental record in the region, offers an unprecedented opportunity to obtain long-term palaeoclimatic information covering most of the Quaternary period. The fact that this region is located on the migratory axis of Hominin populations from Africa to Europe (the oldest Homo erectus fossils in SW Turkey were dated to ca 1.61.2 Ma) renders such climatic reconstructions all the most important.

We use a combination of lithological, geochemical and mineralogical determination techniques (magnetic susceptibility, carbonate content measurements, X-Ray Diffraction, thin sections) to examine the sedimentary history of Lake Acigöl during the Quaternary and try to untangle the respective influences of tectonics, local environmental factors, and climate fluctuations on these deposits' successions. Preliminary results revel a main lithology of lacustrine marls, fluctuating between layers more enriched in detrital (mostly clays and silts) or carbonate fractions, and containing varying evaporite and fossil (ostracods, gastropods, bivalves) contents. The high frequency of alternations between carbonate-rich and detrital-rich layers suggests a climatic control, most probably related to interglacial/glacial cycles. Furthermore, first investigations highlight a positive correlation between arboreal pollen and carbonate percentages, which suggests that carbonate-rich deposits correspond to interglacial periods. On the longer-term, a marked change at ca. 1 Ma towards generally more detrital input may be linked to the mid-Pleistocene climatic transition.

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7000 YEARS OF EARTHQUAKE RECORD IN JULIAN ALPS (LAKE BOHINJ, SLOVENIA)

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We used Lake Bohinj sediments to reconstruct long-term earthquake occurrences in the Julian Alps (Slovenia) because lake sediment sequences are long and continuous records that are sensitive to seismic shaking. A multi-proxy analysis associated with a well-constrained chronology was conducted to reconstruct the Holocene seismic activity. The seismic reflection survey and sedimentological analyses results identified 29 homogenite-type deposits related to 22 mass wasting deposits. For the last several centuries, the results allow us to link the most recent homogenites to historical regional earthquakes (i.e., 1348 AD, 1511 AD and 1690 AD) with strong epicentral intensity (MSK > VIII). This work extends the earthquake chronicle of the last 6600 years in this area. However, the early Holocene sedimentary record is disturbed by a giant seismic event (6617 ± 94 yr cal BP) that reworked previously deposited sediment and led to a thick sediment deposit identified in the seismic survey. In addition, several time intervals without earthquake-induced homogenites appear and could be related to a regional gap of seismic activity or to a change in the lake's sensitivity to seismic shaking. For two of these gaps, there is evidence of sedimentation rate changes that are likely linked to human activity in the watershed, which may have changed the earthquake sensitivity of Lake Bohinj during this period.

EVOLUTION OF DETRITAL CONTENT DURING AN OROGENIC CYCLE: EVIDENCE OF SEDIMENTARY RECYCLING BETWEEN THE CAMEROS MASSIF AND THE EBRO BASIN FROM LOW TEMPERATURE THERMOCHRONOLOGICAL DATA

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Detrital material from sediments preserved in basins provide constraints on source rock natures, sediment transport dynamics, and potentially on tectonics and climate change. With the aim to track sediment source evolution over a single orogenic cycle and determine characteristic time and parameters controlling the geochronological signal preservation throughout the cycle from rifting, mountain building to postcollision evolution, low-temperature thermochronology combined with sediment petrography appear more appropriate than the U-Pb dating approach alone. To better understand processes involved in the preservation of the geochronological signal, we focus on the sediment record associated with the Iberia plate tectonic evolution, which is part of the OROGEN research project, co-financed by BRGM, TOTAL & CNRS.

The Cameros Massif, located in the southwestern border of the Tertiary Ebro basin, is part of the Mesozoic Iberian rift basin inverted during the Cenozoic. It comprises 6 km of Late Jurassic to Early Cretaceous syn-rift series, deposited in continental to shallow-marine environments, and recorded lowgrade metamorphism during the Albian. The Cameros Massif is the perfect target to (1) unravel main processes controlling loss or preservation of the rift thermal signature, from rifting to final exhumation coeval with the Cenozoic Ebro basin development (2) reconstruct both the paleogeography, and the thermal evolution of the northern Iberia during the Early Cretaceous. 400 zircon grains from 7 sandstones sampled in the Cameros Massif and the Ebro basin have been analysed with fission-track dating. Detrital zircon fission track (ZFT) age-distribution in the oldest syn-rift sediments, collected close to the metamorphic zone, indicate a full reset and a temperature recorded above 300°C (consistent with RSCM data indicating maximum temperatures of 393±28°C) before cooling at 56±12 Ma. To explain the thermal maximum and the metamorphism observed, an abnormally high geothermal gradient at the Albian must have taking place in addition to burial heating. Unreset zircon from the Tertiary Ebro basin and the uppermost sequence of the syn-rift series shows two age populations at 179±14 Ma (Pliensbashian-Aalenian) and 106±10 Ma (Albo-Cenomanian), consistent with the two rifting phases described in Cameros and recorded in bedrock ages exposed in the western part of Iberia.

The Cameros basin and the Ebro basin age distributions are similar, suggesting that syn-orogenic sediments collected in the Ebro basin are made of recycled syn-rift sediments. Remarkably, the lack of grains with "Pyrenean" syn-orogenic Late Cretaceous and Cenozoic ZFT ages suggests that exhumation in source rocks remained well below 3-6 km (depending on geothermal gradient) during tectonic inversion. These first results will be compared to other detrital ZFT analyses from the Ebro basin while sediments petrography analyses will allow to identify relative control of source petrography, hydraulic sorting, alteration and diagenesis processes on the signal preservation during sediment transfer.

AN ORBITAL CONTROL ON BEEF DISTRIBUTION IN MATURE SOURCE ROCK ? (VACA MUERTA FORMATION, NEUQUÉN BASIN, ARGENTINA)

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In sedimentary basins, source rocks may generate aqueous and hydrocarbon fluids during burial and diagenesis. This fluid production in very-low permeability sediments is responsible for the development of fluid overpressure, and in some cases leads to hydrofracturing processes. Such processes are evidenced by the occurrence of mineralized fibrous veins distributed parallel to black shale layering in many mature basins, known as “beef” or “bedded parallel fibrous calcite veins”. A link between the beef formation and the total organic carbon (TOC) has been suggested since overpressure and hydrofracturing is most likely to be triggered by a phase transition (solid-liquid) during chemical compaction and thermal maturation of kerogene.

In parallel, the organic matter preservation and TOC evolution in marine sediments are highly influenced by eustatic and climatic fluctuations. At short to medium timescales (< 1.106 yr), these fluctuations are cyclic and influenced by Milankovitch cycles, thus illustrating an orbital control on the stratigraphical evolution of the organic matter content. Considering a presumed relationship between mechanisms of beef generation and the TOC as well as a control of orbital parameters on the TOC evolution, we address the following question: is there an orbital control on the beef distribution in source rock?

Hereby, we present the preliminary results of a field mission aiming to answer this question and performed in the Neuquén Basin (Argentina) during March 2017. We conducted fieldwork in the Loconpué area where the Late Jurassic Vaca Muerta Formation offers exceptional exposures composed of organic matter-rich black shales interbedded with numerous calcite beef of reliable lateral continuity (100’s meters) and thickness (0.2 to 7 cm). We performed a detailed 100 m thick outcrop logging focusing on the beef stratigraphical position, thickness and continuity. In parallel, we carried out a 10 cm interval shale sampling in order to investigate magnetic susceptibility trends in the stratigraphical record. Knowing that the magnetic susceptibility of sediments is a good indicator of the detrital fraction, we aim to decipher a possible climatic and orbital signal in this Late Jurassic sedimentary record. Using these datasets, we later performed spectral analyses on the beef stratigraphical distribution, the beef thickness and the magnetic susceptibility signal to evidence a possible control of orbital parameters on beef distribution.

FLUID OVERPRESSURE IMPACTS ON CLAY REMOBILISATION: NATURAL EXAMPLES, ANALOG MODELLING AND RESERVOIR IMPLICATIONS

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The development of fluid overpressure in surface to subsurface sediments is responsible for the modification of reservoir properties. At regional scale, hydrofracturing and injection of sediments can significantly alter reservoir geometry. At macroscopic to microscopic scales, fluid overpressure often triggers changes in the sediment granular framework and major remobilisations and redistributions of the finer particles. Common structures related to sediment remobilisation include convolute bedding, dishes, pillar structures or dewatering sheets. These structures are combined with a remobilisation of finer particles that may be responsible for the development and redistribution of detrital clay coating, later influencing diagenesis and petrophysical features of sandstones.

To better constrain reservoir heterogeneities, processes of clay remobilization, redistribution and coating should be analysed and their links with fluid overpressure development more clearly identified. To answer these questions, we propose an integrated approach combining macroscopic to microscopicscale core description, petrophysical analyses and analog modelling.

Core analyses were performed in the Late Ordovician glacial sedimentary record of Algeria. We describe pillar structures and injectites related to sediment liquefaction and fluidisation that show clear evidence of clay redistribution in sandstones. These structures are directly related to the development of fluid overpressure during interactions of water-saturated soft sediments and the overriding ice during the Late Ordovician glaciation. Fluid overpressure and clay remobilisation appear to be promoted in layer-cake stratigraphical patterns displaying sandstones interbedded with claystones to siltstones. This clay remobilisation predominantly occurs in the vicinity of clay beds and is associated with the local redistribution of clay coatings in sandstones. Petrophysical investigations and the quantification of clay coating abundance in sandstones show that their local accumulation is responsible for a significant decrease in both porosity and permeability.

In parallel, we used a “Hele-Shaw” cell to experimentally model fluid overpressure and the timing and characteristics of clay remobilisation processes in a “layer-cake” stratigraphy. Indeed, we trigger fluid overpressure by injecting water in a 1.5 cm thick cell filled by interbedded glass beads (70-110 µm) and clay layers (kaolinite < 15 µm). First results show that (1) elutriation is generally constrained to fluidization pipes, (2) the fluidization pipe size seems to influence the elutriation rates and (3) clay remobilisation predominantly occurs upward.

THE MID-CRETACEOUS NATIH FORMATION IN OMAN: A MODEL FOR CARBONATE PLATFORMS AND ORGANIC-RICH INTRASHELF BASINS

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The Natih Formation in Oman is an exceptionally well-exposed large (>1000km) epeiric, shallow marine, tropical carbonate platform system. It has a complex organization due to the presence of two adjacent intrashelf basins and five 3rd-order sequences. A further level of heterogeneity is created by the presence of 4th and 5th order sequences which are well expressed in the high accommodation settings, whereas in low accommodation settings these amalgamate or become condensed in discontinuity surfaces (hardgrounds). Similarities in organization, composition and lithology of the different orders of sequences can be demonstrated, which highlights their fractal character, suggesting the predominant control of the A/S factor at different scales.

A key learning is the observation that facies models change during one 3rd order sequence. During early and slow sea-level rise homogeneous aggradation of a shallow-marine sub-horizontal platform occurred. Subsequently, with an increasing rate of sea-level rise a process of differential aggradation was responsible for the increasing inclination of the depositional profile and for the development of intrashelf basins, where organic-rich deposits were preserved. When carbonate production reached its maximum and exceeded relative sea-level rise, these basins were filled by prograding carbonate wedges characterized by a rudist-rich grainy sedimentation. The phases of sea-level drop were recorded by fluvial incisions on the platform, responsible for heterogeneities at the top of sequences, but karstification phenomena and related diagenetic overprint remained limited. The development of intrashelf basins was thus limited to periods of fast and sufficient accommodation creation.

The type of carbonate producers evolved during the 3rd order depositional sequences from a muddominated primary production at the base and in the transgressive part, to a bioclastic/skeletal grainy sediment production, dominated by fragments of rudists during the highstand period. Similarly, within the intrashelf basin organic matter was produced and preserved during the transgression, but not preserved during the regressive phase, even if the bathymetry of the basin was similar.

Most inner-platform sequences, at different scales, consist of a more or less argillaceous muddy carbonate unit at the base, grading to a more granular rudist-rich unit at the top. Such a coarsening-upward succession of facies should not be interpreted as a shallowing-up parasequence, but quite the opposite, as a very asymmetrical sequence which records mainly a transgressive phase. The grainy deposits correspond to the phase of maximum flooding and highstand on the inner platform, a period during which hydrodynamic conditions and processes of differential aggradation controlled the accumulation of granular bodies characterized by complex geometries.

The distribution in time and space of argillaceous facies within the Natih Formation demonstrates that these come from the southern inland areas (exposed Arabian Shield) and that they do not represent deepwater facies representing an MFS, but quite the opposite, early transgressive very shallow-marine deposits. With continued transgression, argillaceous facies belts shifted back towards the proximal domain in the South resulting in cleaner carbonate deposits in the out-board domain. No argillaceous facies was deposited in the study area during periods of maximum flooding, nor during highstand.

LARGE CARBONATE-FED DEEP-SEA TURBIDITE FAN DEVELLOPED AT THE MOUTH OF A GIANT CANYON ALONG THE BAHAMIAN SLOPE

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Leg 2 of CARAMBAR 2 offshore cruise was conducted from December 20th, 2016 to January 2nd, 2017 in the Bahamas archipelago onboard the R/V L'Atalante. The equipments used during this cruise were a Konsberg EM122/EM710 multibeam echo-sounder, a "Chirp" sub bottom profiler, a high-resolution (HR) multichannel seismic system and a Kullenberg coring system. It provides new high-resolution multibeam and backscatter mapping images, high-resolution (HR) and very high-resolution (VHR) seismic in Exuma Valley and Exuma Canyon located at the mouth of Exuma Sound (southeastern Bahamas). The collected data were used to highlight the valley and the canyon morphologies as well as the sediments processes and transfers trough the Exuma system. Exuma Valley is located in the Exuma Sound distal part and is limited by the steep walls and slopes of carbonate platforms including Conception and Cat islands, Rum Cay, and San Salvador in the north, Long and Crooked islands and Samana Cay in the south. It also cross trough the Crooked Island Passage (CIP). This system works as a transition area between Exuma Sound and the deep abyssal basin bordered by the Blake Bahamas Escarpment (BBE) known as San Salvador Abyssal Plain (SSAP). The valley is structured by a gently sloped U-shaped channel (< 1°) which is 144 km long, 3000 m below sea level, and punctuated by many knickpoints. It plunges in the canyon via two major knickpoints with outsized chutes exceeding several hundred of meters in height, which are interpreted as plunge pools. Exuma Canyon is a Ushaped canyon with a length of 44 km incising a drown Mesozoic platform on 1400 m, rivaling the depth of the Colorado Grand Canyon. The two unprecedented giant plunge pools created by hydraulic jumps are more than 200 m deep and are ten times bigger than subaerial plunge pools created by waterfalls like Niagara Falls. Such structures can be also observed in the tributary south branch of the canyon, the Crooked Canyon which joins the main canyon with another knickpoint. The canyon's mouth leads to a deep-sea turbidite fan with channel/levee systems in the San Salvador Abyssal Plain with pockmarks occurrence along the Blake Bahama Escarpment. As the canyon is not structured by a well-defined head, its supply is carried out not only by gravity flow processes from Exuma Sound upstream but also by sedimentary input originates from adjacent platforms. A dense gullies network is developed along the carbonate slopes of the platforms, draining the Exuma Valley. All the 10 m to 50 m high knickpoints encountered along the valley are the results of the merging between the gullies and the channel. These knickpoints attest the activity of the gullies slopes and thus, testify the off-bank transport coming from the carbonate platforms Long Island, Cat Island, Conception Island, Rum Cay and Samana Cay.

GEOCHEMICAL CHARACTERIZATION OF OFFSHORE DEPOSITS IN A MIXED SILICICLASTIC-CARBONATE MARINE RAMP

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The aim of this contribution is to analyze the inorganic geochemistry and to evaluate proximal-distal compositional variations in late Valanginian – early Hauterivian offshore fine-grained deposits of a mixed (siliciclastic-carbonate) marine ramp (Neuquén Basin, Argentina). Three stratigraphic sections (550-650 m thick) of the Pilmatué Member (Agrio Formation) were logged in a north-south transect of 17 km. A total of 120 samples were processed for geochemical analysis using a handheld X-ray fluorescence equipment (Nitton XL3 Analyzer Thermo Scientific). The elements used for this characterization were: SiO_2, TiO_2, Al_2O_3, Th and Zr, as detrital supply proxies; CaO and Sr as proxies of carbonate productivity; and V, Cr, Co, Cu, Mo and Ni as redox proxies. The obtained results show significant compositional variations both in lateral and vertical direction. The southern (proximal) section is enriched in elements with detrital affinity, while those sensitive of carbonate productivity are more abundant in the northern (distal) sector. Analysis of siliciclastic proxies demonstrated the presence of two main sources of detrital components: one enriched in heavy minerals and with a slightly coarser (silty) grain size (rich in TiO_2 and Zr, and depleted in Al_2O_3), and the other enriched in aluminum and representative of very fine-grained (clay rich) siliciclastic deposits. Analysis of temporal evolution of the record shows an increase in siliciclastic components towards the top of the succession, which is attributed to progressive raise in terrigenous contributions during the progradation of the ramp system in a highstand stage. The analysis of carbonate proxies revealed the presence of favourable conditions for carbonate productivity in distal (north) sectors as well as in the mid-lower section, associated with the transgressive stages of the system. The redox proxies indicate that low levels of oxygenation prevailed in the distal sectors (north) and in the lower and middle sections of the unit, coincident with the maximum productivity of carbonates. Thus, during the transgressive stage, the input of oxygenated water and terrigenous supply was remarkably deficient. In contrast, the subsequent highstand conditions favoured the activity of marine currents which allowed redistribution offshore of terrigenous components, an increase in the oxygenation of waters (low concentrations of redox sensitive elements), and a significant decrease in carbonate productivity.

DEPOSITIONAL EVOLUTION LAWS IN SMALL FAULT BASIN OF WANG GUANTUN OILFIELD IN HUANGHUA DEPRESSION

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Wang guantun oilfield is located in the Kongnan area of Huanghua depression in China. It is a small fault basin formed in Paleogene. Comprehensively analyzing data of 224 coring wells, combined with seismic and logging data, redefiniting the main types of sedimentary facies in the small fault basin. Studying the depositional evolution laws and analyzing the main controlling factors of the depositional evolution.

In the period of Kongdian group in Paleogene, there had experienced semideep-deep lacustrine facies, braided river delta, nearshore subaqueous fan, fan delta, alluvial fan and gypsum salt sedimentary facies evolution process. K2 formation, the earlier depositional period of Kongdian group, were mainly semideep-deep lacustrine facies, braided river delta and nearshore subaqueous fan sedimentary systems. At the initial stage of K2 formation depositional period, the climate was damp, the range of lake was large, and the sedimentary source recharge was less abundant, the range of fan on land was small, led to braided river delta and nearshore subaqueous fan sedimentary facies when the sediments went into the lake. To the K1 formation depositional period, the climate turned to dry-hot and the water area of lake basin decreased. In the early-time of the K1 formation, as the tensional stress of the Xuxi fault, the eastern source area uplifted, sedimentary source recharge increased, the range of the fan increased, led to fan delta sedimentary facies when the fan sediments went into the lake. In the mid-time of the K1 formation depositional period, the climate was dry, and the water area of lake basin decreased continuously, at the same time, sedimentary source recharge was abundant, mainly developed fan delta sedimentary facies. To the late-time of K1 formation depositional period, the alluvial fan declines gradually, sedimentary source recharge was less abundant, and the dry-hot climate made the lake turn to a saline lake, gypsum salt sediments developed.

On the whole, the water area of the lake basin has experienced the change process of increasing, then decreasing and increasing again. The sedimentary source recharge has experienced decreasing, then increasing and decreasing again. From K2 formation to K1 formation deposional period, the climate turned damp to dry. These factors influence and control the laws of depositional evolution.

DISTRIBUTION CHARACTERISTICS OF OIL SANDSTONE AND MAIN CONTROLLING FACTORS IN WANGGUANTUN OILFIELD

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Wangguantun oilfield is located in the south of Kongdian salient in Huanghua Depression in China, the z2 group is the majoy production bed. Sedimentary facies in study area is braided river of alluvial fan. It belongs to medium porosity and medium permeability reservoir. From the two aspects of sedimentary and diagenesis, we analyzed the main factors of oil sand bodies distribution.

Sedimentary microfacies has an important influence on the distribution of oil sandstone. As for the braided river of alluvial fan in z2 group, 78% of oil-rich sandstones are mid-chinnel bar, and only 22% are braided channel. Facies controls the development of sandstones, and different kinds of sandstones have different physical properties, thereby, the differences of reservoir quality lead to the differences of oil-bearing properties. According to the data analysis of 19 coring wells in Wangguantun oilfield, we can know that the porosity and permeability of mid-channel bar are higher than those of braided channel, the shale content of mid-channel bar is less than that of braided channel, thus, oil-bearing property of mid-channel bar is bettter than that of braided channel sandstone.

Quality of the reservoir in the study area is closely relatedly to diagenesis facies, which has apparently controlled on the distribution of the oil-rich sandstone. the diagenesis facies in study area can be divided into 3 types: corrosion diagenesis facies, weak cementation diagenesis facies, and compaction diagenesis facies. Reservoir of corrosion diagenesis facies is mainly distributed in the sandstone of mid-channel bar. With porosity larger than 20% and permeability larger than 100×10^{-3} μm^2, it is the best reservoir of the study area. Cementation diagenesis reservoir is mainly distributed in braided channel. Since it has a relatively high content of interstitial material, reservoir quality is poorer than that of the corrosion one, with porosity generally between 15%~20% and permeability between 50~100×10^{-3} μm^2. In the sandstone of the edge of the channel, detrital grains are fine and the content of heterobase is high, which leading to strong compation. Therefore, the main reservoir space of compation diagenesis is micro-pores developing in the clay heterobase. With porosity smaller than 15% and permeability smaller than 50×10^{-3} μm^2, the reservoir quality is quite poor.

THE SEDIMENTOLOGY AND ARCHITECTURAL CHARACTERISTICS OF SANDY BRAIDED RIVER

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The sedimentary facies is sandy braided river In the west of 7th block in GuDong oilfield of China. According to the core, logging and production performance data of the dense well pattern area, we classified architectural units of the braided river, identified 7 kinds of mid-channel bar and 4 kinds of braided channel filling architectural units, illustrated by the case of 7th block in GuDong oilfield, which was typical sand braided river sedimentation. Among which, the main types of logging curve characteristic through mid-channel bar are box type, composite box type, geared-box type, high amplitude bell type, composite bell type, composite circular type and funnel type. The main types of braided channel filling sand bodies are sand filling type, sand with thin shale layering filling type, sand in the bottom and shale in the top filling type and shale filling type. Multiperiod single mid-channel bar sand bodies deposit superimposedly to form a composite bar. Taking the ancient braided river outcrop as a guidance, according to the braided channel filling sand bodies between different bars, the different thickness of adjacent bars, the different changes of sedimentary rhythm, unmatch of the interlayers in different bars, the differences of logging curve characteristics and dynamic data which reveals the disconnected signs, identify the single bar. We Identified 5 single mid-channel bars, belonging to 4 times and divided them into two different depositional types, as the same time with different position type and the same layer with different time type. According to the 5 level braided river, 4 level single micro facies (single mid-channel bar and single braided channel filling sand bodies), 3 level interlayers in single mid-channel bar, quantitatively analyzing the braided river reservoir architectural models. In the study area the thickness of sand bodies is large, and the hydrodynamic changes frequently, so there are kinds of interlayers developing in the sand bodies. According to the core, well logging data from the dense well pattern area, we recognized different levels and patterns of interlayers in braided river sand bodies, and quantitatively evaluated the insulation and sealing ability of the interlayers to oil and water movement, combined with dynamic production data, we summed up the patterns of the remaining oil enrichment.

CONTROLS ON THE TURNOVERS OF PLATFORM SLOPE GEOMETRIES AND COMPOSITION (MALDIVES, INDIAN OCEAN)

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Changes in carbonate platform slope geometries and facies are indicators of environmental changes as sea-level fluctuations or oceanographic reconfigurations that may be linked to global phenomena. The Maldives contain a carbonate edifice that bears a unique and mostly unread Indian Ocean archive of the evolving Cenozoic icehouse world. The study of seismic profiles, facies and microfacies, and ichnofabrics of the Oligocene-Miocene platform slopes retrieved during IODP Exp. 359 allowed reconstructing the different stages of basin evolution. These data were used to characterise the palaeoenvironmental conditions of the platform slope deposits, as well as subtle changes of the slope depositional regime controlled by variations in the frequency and intensity of the platform shedding and the current regime. Four stages of slope evolution were identified including 1) a restricted basin interval, 2) a ramp to slope transition, 3) an aggrading platform with margin edge and steep slopes, and 4) a prograding platform with hanging shoulders. The different stages of basin development are separated by turnovers marked by key surfaces with abrupt changes in the fossil assemblage, the ichnofabrics and the natural gamma ray values. Sea level is proposed as the main controlling factor of the composition and architecture of the platform slopes, with a clear link between platform-sequence boundaries and global sea-level lowstands. Other global events, as the Miocene Climate Optimum, are also recorded in the facies and ichnofabrics. The last stages of the basin evolution show an increasing significance of currents flowing to the East from the Indian Ocean into the Inner Sea of the Maldives. The currents controlled slope geometries, facies and ichnofabrics. This current system may be anticipatory of the onset of the South Asian Monsoon that terminated with the platform development and initialized the drift deposition in the Maldives.

FACIES AND STRATAL PATTERNS OF A SYN-RIFT SEQUENCE ALONG A FOSSIL HYPEREXTENDED RIFTED MARGIN: THE EXAMPLE OF THE ALPINE TETHYS MARGIN IN THE CENTRAL ALPS

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Research on the formation and evolution of deep-water rifted margins has undergone a major paradigm shift in recent years. An increasing number of studies of present-day and fossil rifted margins allows us to identify and characterize the architecture of hyperextended rifted margins. However, at present, little is known about the depositional environments, sedimentary facies and stratal patterns in syn-rift sequences within these domains. Characterizing and understanding the spatial and temporal evolution in such contexts is a new challenge.

The syn-rift sequence at rifted margins is deposited during the initial stages of stretching to the onset of oceanic accretion and comprises pre-, syn-and post-kinematic deposits along the margin. A difficulty arises from the fact that the observed stratigraphic geometries and facies relationships result from the complex interplay between sediment supply and creation of accommodation, which in turn are controlled by regional synchronous events (i.e. crustal necking and onset of seafloor spreading) and diachronous events (i.e. migration of deformation during rifting, lags in sediment input to the distal margin); such parameters being poorly constrained in hyperextended rift systems.

In our presentation, we show preliminary results for fossil Alpine Tethys margins exposed in the Austro-alpine nappes in SE Switzerland. Sedimentological fieldwork was carried out involving detailed facies mapping and time-line identification to constrain spatial and temporal changes in the facies associations, as well as the stratigraphic thicknesses and stratal patterns of the Jurassic sedimentary successions. We discuss the parameters controlling the Jurassic syn-rift depositional sequences and provide a conceptual framework to correlate the deposits throughout the rifted domains. The ultimate aim of this work is the identification of correlative surfaces and unconformities, separating genetically related packages observed within different rift domains along hyperextended rifted margins.

DESTABILIZATION OF TROPICAL ISOLATED CARBONATE PLATFORMS

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Landsliding processes are relatively well-constrained on clastic sedimentary margins but remain poorly documented along carbonate slope and guyots. The southern central Mozambique Channel, between Mozambique and Madagascar, hosts several isolated carbonate platforms called the "Iles Eparses" and adjacent seamounts, which developed in shallow-water and tropical settings during the Miocene. They underwent several periods of subaerial exposure that were responsible for the formation of widespread karstic morphologies. Cessation of the shallow-water carbonate production and the drowning of these platforms occurred during Middle MioceneEarly Pliocene times.

Geophysical acquisitions carried out during recent oceanographic cruises (Pamela Projects – Ifremer/Total collaboration) on the flanks of two guyots (the Hall and Jaguar banks) and of one modern atoll (Bassas da India) display a complex geomorphology dominated by numerous lineaments (recent tectonic activity), volcanic mounts, slope scarps, residual translated blocs and gullies. The three carbonate platforms are damaged by large headwall scarps. Geomorphological analysis of their flanks reveals distinct geometries between blocks and small volcanic mounts. Seismic data investigation of the northern flank of the Jaguar bank shows that blocks correspond to triangular-shaped sedimentary bodies (up to 400 m thick and up to 800 m wide) composed of transparent seismic facies. It suggests they are remnant blocks resulting from the destabilization of the platform.

Between blocks, small perched basins are characterized by a sub-parallel seismic facies. The samples recovered by an 8 m Calypso core (Moz1-KS28) in a thick perched basin confirms a hemipelagic sedimentation and dating obtained from nannofossil assemblages allow to propose that destabilization occurred before the Pliocene. Assuming a constant sedimentation rate inside this perched basin (60 m thick), we estimate this failure event to have occurred during the end of Eocene probably before the development of the carbonate platform. The blocks may be of a volcanic origin linked to a destabilization which occurred during the early stage of the edification of the Jaguar bank, and may be interpreted an epiphenomenon of the growth of the volcanic mounts.

The sedimentation rate in the perched basin remains poorly constrained. If it is greater than the one used here, the destabilization would occur during the Miocene, after the growth of the seamounts and the failure process would be very different: (1) carbonate dissolution and erosion processes during exposures or subaerial stages, (2) tectonic activity revealed by high-amplitude vertical motions and dense faulting observed along the seamount, (3) intense seismicity observed along a fault corridor observed in the southern Mozambique channel crossing the three seamounts studied here. The origin of the destabilization process of seamounts remains an active on-going debate and is a subject poorly studied as yet.

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GLOBAL SPECIES RICHNESS RECORD OF THE EARLY TO MIDDLE NEOPROTEROZOIC

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Over the past several decades, a number of studies have addressed the record of eukaryotic species richness in the Proterozoic, each clearly indicating that during the Neoproterozoic Era, in particular, tremendous changes occurred in Earth's biota. The relative scarcity of radiometric age constraints for rocks of this interval, however, have necessitated the use of coarse time bins (~100 Ma) and the omission of fossiliferous but poorly dated units, resulting in low resolution of eukaryotic richness trends. Here we present a new estimate of early to middle Neoproterozoic (Tonian and Cryogenian) eukaryotic richness developed by use of the CONOP seriation algorithm; this approach permits inclusion of poorly dated and un-dated units and allows for greater resolution.

The CONOP (constrained optimization) algorithm operates by evolutionary ordination-considering evidence of stratigraphic order from all locations simultaneously and starting from a random ordinal sequence that improves by mutations retained or removed according to best-fit rules. This program has been applied successfully to biochronologic and biostratigraphic problems throughout the Phanerozoic geologic record. Here we apply this objective approach to the Proterozoic with a new compilation of taxonomically well-constrained organic-walled microfossil occurrences as well as geochemical, sedimentological and geochronological data from more than 160 formations from 58 groups in paleogeographically distant successions.

From this dataset we developed a high-resolution eukaryotic species richness record for the early to middle Neoproterozoic Era (~1000 to 635 Ma). This new estimate of eukaryotic species richness indicates an increase in richness began ~800 Ma and continued towards a peak ~770 Ma when it declined with the losses of many long-lived taxa. The overall decline is punctuated by a sharp richness increase ~738 Ma due to the iconic and short-lived Tonian vase-shaped microfossils (VSM) taxa such as *Cycliocyrillium simplex*. These VSM taxa were lost ~733 Ma and richness continued to decline until flat-lining well in advance of the ~720 Ma onset of the Cryogenian Snowball Earth glaciations. Eukaryotic species richness did not rebound until after the termination of the second Cryogenian glaciation when a new suite of acritarch taxa appeared in the Ediacaran Period.

In addition to providing insight into eukaryotic richness trends, these analyses result in construction of a hypothetical global composite section that includes all geochemical events (carbon isotopic excursions), sedimentological events (Snowball Earth glaciations) and taxonomic first and last appearances. From this hypothetical composite section, best estimates can be made for stratigraphic ranges of potential biostratigraphic index taxa and for global correlation of fossiliferous sections. An estimate of section correlations places much higher demands on the local information, and entails large uncertainties, but leads to testable predictions for new occurrences of geochemical, sedimentological and paleontological events.

INTEGRATED STUDY OF AN OLIGO-MIOCENE SUBTROPICAL CARBONATE SYSTEM (NORTHERN CARNARVON BASIN, WESTERN AUSTRALIA)

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The Northern Carnarvon Basin (NCB) on the North West Shelf of Australia is a premier hydrocarbon province. Reservoir rocks are overlaid by thick carbonate deposits associated with blow out risks and velocity anomalies. While past studies have documented the main facies and seismic geomorphologies of these sequences, their detailed depositional history is still poorly understood and models predicting the regional distribution of facies are not available.

The study aims to produce a new stratigraphic model for the Oligocene-Miocene sequences of the NCB. Oligocene-Early Miocene sequences are deposited in a distally steepened ramp dominated by the shallow foraminiferal packstone deposits of the Tulki limestone and the finer-grained, deeper water deposits of the Mandu calcarenite. A platform covered with patch reefs forms during the Middle Miocene and the shallow foraminiferal wackestone of the Trealla limestone are deposited. Proximal deposits are outcropping in the Cape Range anticline. Their distal equivalents are not outcropping but are covered by extensive offshore 2D/3D seismic and well data. Existing studies are focusing on either lithostratigraphy and large benthic foraminifera (LBF) assemblages onshore or seismic stratigraphy and planktic foraminifera offshore. To date, there is no documented basin-scale stratigraphic model nor onshore-offshore correlation.

This integrated study is based on field data, thin section and acetate peel analysis, strontium isotope age dating, biostratigraphy and 3D seismic interpretations. Results are confirming that the Oligocene-Early Miocene sequence was deposited in a regressive cycle along a distally-steepened ramp covered with extensive sea grass meadows. Shallow water LBF, red algae and echinoderms grains were broken by burrowing organisms and waves, and continuously reworked on the distal part by wave action to form prograding clinoforms. Sediment transport at the distally steepened end of the ramp resulted in the formation of small linear gullies.

Sea level fall culminated during the Middle Miocene Climatic Optimum, with platform exposure and possible karst development during repeated major eustatic lowstands. Supratidal microbialites were formed and the platform was partially dolomitized.

Flooding of the platform following the middle Miocene transgression resulted in the establishment of a warmer, less energetic and more saline environment. The system transitioned to a locally rimmed platform, favorable for patch reefs and encrusting red algae growth. LBF and carbonate mud accumulated on the shelf and were episodically transported basinward through gravity driven processes which resulted in the formation of large channelized turbiditic systems. Carbonate platform production ceased during the late Miocene after a phase of siliciclastic influx from the continent. This event coincides with the onset of tectonic reactivation along Australia's North West Shelf and with the uplift of the Cape Range anticline.

This work highlight how integrated studies can improve the understanding of the combined eustatic, tectonic, biologic and oceanic controls on carbonate platform stratigraphy.

THRESHOLDS OF MOTION OF SHELL DEBRIS UNDER UNIDIRECTIONAL FLOW: INFLUENCE OF FAUNAL COMPOSITION

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Understanding bottom sediment erodibility is necessary to refine our interpretation of depositional environments in the fossil record and to improve predictive numerical models for coastal zone management. Many coastal sediments are partly composed of biogenic particles, which shapes and densities differ strongly from classic rounded quartz grains. This results in particular hydrodynamic behaviours. Characteristics of biogenic particles can also vary significantly between species. If numerous studies have investigated the hydrodynamic behaviour of bioclastic sediments derived from reef-dwelling organisms, there is a paucity of research focusing on "cool-water carbonate" bioclastic particles (i.e. mollusc shell debris, calcareous algae,...). The aim of the present research is to characterize the influence of faunal composition on the entrainment threshold of mollusc shell debris from temperate regions. Shells have been sampled in the southern coast of Mont-Saint-Michel bay (Brittany, France) which is bordered by a coarse, shelly coastal barrier, before being ground and separated into individual sieve fractions. Eight species representative of the faunal composition in the area have been studied: four wild species (*Cerastoderma edule, Scrobicularia plana, Anomia ephippium, Ostrea edulis*) three reared species (*Crassostrea gigas, Mutilus* sp., *Ruditapes philippinarum*) and one introduced (*Crepidula fornicata*). A set of experiments have been performed in a small recirculating flume. Threshold of motion of the eight species under unidirectional current for several debris sizes have been characterized using an Acoustic Doppler Velocimeter Profiler. Critical bed shear stress values (taucr) were derived from velocity profiles in the boundary layer, by a logarithmic regression of the "law of the wall". Depending on the species, the evolution of taucr with increasing grain diameters follows either an asymptotic or a more linear trend. Significant disparity of entrainment threshold is observed between species, which increases with particle sizes. Three groups can be discerned*: Anomia ephippium, Crassostrea gigas* and *Ostrea edulis* show the smallest taucr, *Crepidula fornicata, Scrobicularia plana, Mutilus* sp. for an intermediate taucr and *Cerastoderma edule*; *Ruditapes philippinarum* for the highest taucr. For example, for the sieve fraction 2-3.15 mm, Anomia ephippium is the first to move with a taucr of 0.38 $N.m^{-2}$, and *Cerastoderma* edule shows the highest critical shear stress (taucr = 2.13 $N.m^{-2}$). Oyster shells (*Ostrea* and *Crassostrea* sp.) are mainly composed of foliated sheets of calcite, sometimes interstratified with soft, porous and chalky material. These two structures present very different thresholds of motion (e.g. for 2-3.15 mm sieve fraction: 0.54 $N.m^{-2}$ for the chalky material, and 1.08 $N.m^{-2}$ for the foliated calcite sheets). Globally, the interspecies variations of hydrodynamic behaviour can be attributed to differences in shell density, shell structure, grain shape, or to a combination of these three parameters.

SEDIMENT FILL AND TSUNAMI DEPOSITS IN THE PAGO PAGO BAY, TUTUILA ISLAND, AMERICAN SAMOA

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The South Pacific Tsunami (29th Sept. 2009) severely hit the Tutuila volcanic island (American Samoa) and caused significant damage along the shoreline and more than 30 deaths. A tsunami wave is composed of two main successive stages: the uprush and the backwash resulting in the deposition of subaerial and marine sediments on the coastal plain and offshore respectively. In general, shallow marine deposits have a low preservation potential because of reworking by hydrodynamic agents and bioturbation mainly. We focus on Tutuila, a volcanic island characterized by an indented shoreline, including a highly sheltered and deep bay (Pago Pago Bay), where the preservation potential of shallow marine deposits related to the South Pacific Tsunami (29th Sept. 2009) may be exceptional.

We present preliminary results from an extensive seismic and bathymetric exploration combined with sedimentary core sampled in the Pago Pago Bay (SAMOA-SPT cruise, R/V Alis, August-September 2015). Interpretation of the seismic survey shows that the sedimentary infilling of the bay reaches about 10 to 15 meters in thickness. The sediment bay-fill can be subdivided in 6 transgressive and aggradational units underlined by subhorizontal and subparallel reflectors with strong changes of acoustic impedance suggesting important grain size variations. Core-to-seismic correlations of the two uppermost units show that they are dominated by carbonate-rich silt deposits alternating with coarse intervals, mainly composed of allochtonous gravel-sized coral fragments. Specifically, the top silty interval (seismic unit U6) is very well sorted and does not show any vertical grain size trend, but it can contain inframillimetric coral fragments, coarser at base. Meanwhile, the magnetic fabric of this uppermost silt interval attests to deposition under alternated currents. The chemical composition (XRF) of silty intervals shows positive anomalies for Pb, Zn, Ti, Zr and Fe, suggesting terrestrial inputs. Below seismic unit U6, seismic unit U5 thins and pinches out seaward. The reflector at the top of U5 is chaotic and discontinuous (seismic horizon H6) while the reflector at base is mainly continuous and subhorizontal (seismic horizon H5). Seismic unit U5 is composed of coarse coral fragments and displays grain size fining landward.

The coarse seaward thinning seismic unit U5 is interpreted to record tsunami inflows bringing coral fragments from the external barrier into the bay, while the base of the silt intervals (U6) is interpreted as mud deposition during ebbing backwash giving way to normal background sedimentation. Further dating will be made to confirm the age of the observed sequence composed of basal coral fragments and upper silt layer. Lower units identified on seismic data were not reached by cores (seismic units U3 and U4), but given that they show the same characteristics as the two uppermost units (seismic units U5 and U6), they could correspond to similar sediment records of older tsunami deposits. Onlapping of seismic unit U1 on the acoustic basement is interpreted as recording early transgressive sediment-fill of the bay.

SEDIMENTOLOGICAL CONSTRAINTS ON THE UNROOFING HISTORY AND GEOMORPHOLOGICAL AND PALEOCLIMATE CONDITIONS ALLOWING SUPERGENE AND EXOTIC CU MINERALIZATION FROM PORPHYRY COPPER: THE CENTINELA MINING DISTRICT, ATACAMA DESERT

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The Centinela Mining District (CMD), Atacama Desert (northern Chile), includes several mid-late Eocene porphyry Cu deposits that contains supergene mineralization and provides access to a record of gravel deposits that host syn-sedimentary exotic Cu mineralized bodies. By studying these gravels, we reconstruct the unroofing history and constrain the geomorphological conditions that produced supergene and exotic Cu mineralization. We present an integrated study based on stratigraphic and sedimentological data, lithology clast counts, $^{40}Ar/^{39}Ar$ and U/Pb ages from interbedded tuff layers and U/Pb detrital zircon geochronology data. To relate the gravel deposition episodes with the timing of the supergene mineralization, we provide in-situ and exotic supergene mineral ages ($^{40}Ar/^{39}Ar$ and K-Ar).

Six gravel units were deposited between the mid-Eocene to the mid-Miocene. The Esperanza gravels were deposited concurrently to the emplacement of porphyry Cu deposits at depth. The subsequent Tesoro I, II and III and Atravesado gravels register the unroofing of these deposits, from the advanced argillic zone to the sericitic and prophylytic hypogene zones. The Arrieros gravels register the landscape pediplanation, i.e. denudational removal and wear of the landscape to base level on a relatively stable tectonic regime, occurring roughly contemporaneous to the supergene activity. Recently published thermochronological data from the CMD allow to refine the geochronology of the porphyry Cu deposits unroofing. The porphyry Cu deposits underwent a relatively rapid cooling since their emplacement at ~45-~41 Ma until ~30 Ma, which can be associated to the increasing stage of landscape evolution. After 30 Ma the porphyries underwent a relatively slow cooling related to low exhumation rates, which represents the early waning relief stage of landscape evolution and the subsequent landscape pediplanation. On the other hand, the supergene mineral ages of the CMD define a time span (~25 to ~12 Ma) during which concentrates most of the supergene ages in northern Chile. Thus, a time shift between the main post-Incaic exhumation and the supergene copper mineralization episodes of the order of 10 to 20 Ma can be deduced from the thermochronology data and the supergene mineralization ages presented herein. Finally, the time span during which supergene mineralization occurs corresponds to a period of warm and humid climate conditions in the southern hemisphere.

We conclude that the landscape pediplanation favors supergene mineralization and helps preserve the former supergene mineralized zones from significant erosion. Pediplanation requires the prevalence of a relative wetter (semiarid, > 100 mm/yr) climate condition to efficiently allow the supergene mineralization processes to occur. Low erosion rates during pediplanation may constitute a necessary condition for the efficiency of the supergene processes in such semiarid climate condition.

LARGE-SCALE EROSION AND DEPOSITION DURING THE LAST GLACIAL-INTERGLACIAL CYCLES ON THE MID NORWEGIAN MARGIN

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During the last c. 2.7 My, large quantities of glacially-derived material were transported westwards from the Norwegian mainland and inner shelf areas, and deposited mainly as prograding sediment wedges into a basin of intermediate depth offshore Mid Norway. Compared to Paleogene and Neogene, the sedimentation rate increased at least one order of magnitude. The Quaternary sediments make up the Naust Formation reaching a thickness of up to 1000-1500 m on the outer shelf. It has been subdivided into 5 main sequences (N_A_U_S_T). Each of the three oldest sequences consist of several prograding units, comprising both glacial debris and glaciomarine/marine sediments. Here we focus on the geological development during the last c. 400 000 years when the sequences S and T were deposited. The sedimentary record includes at least three glacial-interglacial cycles, and the sequence stratigraphy reflects the cyclic climatic changes.

During Naust S time (c. 0.2-0.4 Ma) the glaciers eroded a wide and deep paleo-channel on the shelf, and deposited an up to 350 m thick unit of glacial debris west of the shelf break in the Skjoldryggen region (c. 65°N) where the shelf is at its widest. This acoustically massive unit which wedges out sharply on the mid-lower slope, most likely belongs to the third last glaciation (Elsterian). The rapid deposition of glacial debris influenced the slope stability, and a large submarine slide was triggered (Sklinnadjupet Slide). Stratified sediments (contourites) were trapped in the slide scar, and farther downslope hemipelagic sediments settled. In the palaeo-channel east of the shelf break, up to 40 m of stratified sediments were deposited during the deglaciation and the following postglacial period.

Sequence Naust T was deposited during the two last glacial-interglacial cycles. On the shelf and upper slope it comprises mainly units of till and glacial debris. West of where the glacial debris pinches out on the upper slope, hemipelagic sediments are extensively distributed. South of the Skjoldryggen slope, the thickness of stratified sediments (S&T) increases to c. 250 m, directly north of the holocene Storegga Slide. large slides have occurred earlier in the Storegga area, the second last one probably in Naust S time. The interbedded sequences of fine-grained sediments and glacial debris had a negative influence on the stability.

During the Saalian glaciation the most active glacial drainage path was through the Sklinnadjupet palaeo-trough. Numerous wedges of glacial debris ('till tongues') prograded westwards, making the palaeotrough shallow enough for the ice sheet to ground and thus advance to the shelf break. Finally, glacial debris flowed into the eastern part of the Sklinnadjupet Slide above the stratified sediments of sequence Naust S.

The Weichselian ice sheet reached the shelf edge along the entire margin, and the 150 km long and 100 m high Skjoldryggen ridge was formed in the study area. This probably prevented glacial debris to be far distributed to the west. The very irregular topography east of Skjoldryggen is indicative of glaciotectonic processes.

IN A PICL: THE UNIQUE SEDIMENTARY FACIES OF PERENNIALLY ICE-COVERED LAKES

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Perennially ice-covered lakes (PICLs) can have significantly different facies than open-water lakes because sediment is transported on to the ice where it accumulates, and sand grains preferentially melt through to be deposited on the lake floor. To characterize the facies in these lakes, sedimentary deposits from five Antarctic PICLs (lakes Untersee, Vanda, Fryxell, Hoare, and Joyce) were described using lake bottom observations, underwater video and images, and sediment cores. Lake Untersee was dominated by laminated microbial mat and mud (derived from a melting glacier), with disseminated sand and rare gravel. The other four lakes were dominated by laminated microbial mat and moderately well to moderately sorted medium to very coarse sand with sparse granules and pebbles; they contained very little interstitial or laminated mud. The sand was disseminated or localized in mounds and m scale elongate ridges. Mounds were cm's to m's in diameter; conical, elongate, or round in shape; and isolated or deposited near or on top of each other. One of the ridges contained a track of sediment mounds, analogous to beads on a necklace. Sand layers in the mounds had normal, inverse, or no grading.

Generally, sediment in PICLs tends to be bimodal, with mud settling from suspension and sand being deposited from the ice. PICL facies vary based on the relative proportion of mud to sand and the style of sand deposition through the ice cover (disseminated or localized). In the sedimentary record, these would be preserved as nine related lithofacies, ranging from laminated mudstones to massive sandstones. While PICLs have overlapping facies with other ice-influenced lakes and glacio-marine settings, PICLs are characterized by the paucity of grains coarser than granules, a narrow range of sand grain sizes, and occasional inverse grading in sand mounds.

PICLs facies can be used to infer changes in ice cover through time as well as to identify perennially ice-covered lakes in the rock record. Distinguishing the deposits of PICLs from other lakes in the sedimentary record will provide new insights into past climatic conditions. Presently, PICLs do not form outside of polar regions. However, Earth has undergone glacial-interglacial and possibly pan-glacial states (“Snowball Earth”) where lakes would have permanently frozen over at other latitudes. The extent of ice cover and terrestrial conditions of past “Snowball” glaciations are highly debated. The identification of PICLs during proposed “Snowballs” would constrain climatic conditions at the time because modern PICLs require a specific balance between meltwater influx, heat loss, and ablation to persist. PICLs that do not entirely freeze can provide stable refugia for protists and microscopic animals. Thus, PICLs may have provided refugia for early animals during Neoproterozoic “Snowball” glaciations. Paleo-lake deposits from the proposed Marinoan pan-glaciation have been identified in the Wilsonbreen Formation of Svalbard and are great candidates to analyze for evidence of a perennial ice-cover. Ancient PICLs are also expected on early Mars. The recognition of PICL deposits in the sedimentary record of Mars would constrain the climate transition from a possibly warm-wet Mars to the current cold-dry conditions.

SINK MEASUREMENT OF THE ZAMBEZI SYSTEM (DELTA TO DEEP-SEA FAN): A RECORD OF THE EAST AFRICAN RIFT UPLIFT AND ASSOCIATED CLIMATE CHANGES

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The Zambezi deltaic system is one of the largest in Africa after the Niger, the Congo and the Nile. This passive margin-scale delta is characterized by a topographically and tectonically segmented depositional profile studied in the frame of the project PAMELAPassive Margin Exploration Laboratoriesfounded by TOTAL and IFREMER): (1) an upstream 10 km thick deltaic wedge with no gravitary tectonics, (2) the Angoche pounded deep depositional area and (3) the Zambezi deep-sea fan, bounded fromm the Angoche are by a major contouritic drift.

The sink measurement was based on the seismic stratigraphic analysis of numerous regional seismic lines (from the upstream part of the margin to the abyssal plain) merge of industrial and academic data, calibrated in ages and lithologies on reevaluated wells to get the best possible ages. Volumes measured between successive time-lines, were compacted for a comparison with solid eroded volumes. Uncertainties were calculated (including ages, time-depth conversion law, porosities...) using the VolumeEstimator software.

Four main periods of sediments delivery were identified: (1) 94-66 Ma (Turonian-Maastrichtian) first silicilastic imput, (2) 66-34 Ma (Paleocene-Eocene) – very low siliciclastic supply, (3) 34-5.5 Ma (Oligocene-Miocene) – second input of siliciclastic sediments and 5.5-0 Ma (Plio-Pleistocene) – sharp increase of the sediment supply.

These changes correspond to major deformation and/or climate changes. The reconstruction of the climate (precipitation) evolution was based on a palynological study along wells of the Zambezi Delta and summarized as follows: 100 to 90 Masemi-arid, 90 Ma (base Coniacian)sharp increase to very humid conditions up to 40 Ma, 40-30 Ma and 15-11 Ma dryer periods, 30-20 Ma and 11-7 Ma very humid conditions again.

(1) The 94-66 Ma first siliciclastic sediments supply can be related to the uplift of the South African Plateau and the erosion of the Bushveld reentrant. This can be enhanced after 90 by the sharp increase of the humidity.

(2) The 66-34 Ma period of low siliciclasctic supply is both a period of tectonic stability, very humid conditions and then of intense weathering with carbonate platforms.

(3) The 34 Ma second increase of siliciclastic sediments results from an African-scale upliftrelated to mantle dynamics – onset of a mechanical erosion of the Eocene weathering profiles.

(4) The sharp increase of sediment supply around 5.5 Ma result from more local processes. They are no major climate changes with an amplitude higher than the other Neogene variations. This even is related to a major change of the drainage pattern of the Zambezi River at time of the initiation of the Malawi Rift.

IF CRUSTAL AGES VARY WITH DEPTH, ZIRCON AGE-FREQUENCY MAY BE MORE A FUNCTION OF TECTONICS (EROSIONAL DOWNCUTTING) THAN OF PROVENANCE

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The Yangtze Block, constituting the north-western half of the South China Craton, is thought to be primarily Palaeoproterozoic in age. There are few Archaean outcrops, and most crystalline basement is Palaeoproterozoic, punctuated by mid-Neoproterozoic granites. The zircon record of its sedimentary basins in the mid Neoproterozoic has been more intensively sampled than that of all other regions put together, allowing us insight into sedimentary processes that, globally as well as in South China, were dominated by rifting.

Here I present a compilation of detrital zircon data for the Yangtze Block from c. 860 Ma, when the region first experienced major rifting, down to c. 640 Ma. Sifted for discordance, youngest U-Pb ages are used to date the approximate depositional age of each sedimentary unit, and all ages grouped into the following intervals: < 1200 Ma, 1200–2000 Ma, and > 2000 Ma (Groups N, MP and AP). Group AP captures Archaean zircons plus those whose age was reset by remelting of the crust prior to 2000 Ma. Group N captures the period of greatest zircon frequency in the sedimentary record (by far). As confirmed by Hf isotopes, zircons dating to < 1200 Ma mostly reflect further remelting of the crust rather than arc accretion. The upper crust is therefore inferred to have been layered: largely AP through its upper layer, largely N (replacing AP and M) through its lower layer.

The relative proportions of the three groups varied markedly and systematically with time, but nearly all formations show a high proportion of Group N. Within 40 Ma, i.e. 860–820 Ma, the proportion rose from ~25% to 60–95%, then fell in the subsequent 50 Ma back to ~25%. The rise is interpreted to reflect increasing granitoid magmatism, the ascent of granitoid magmas to higher levels in the crust and erosional downcutting into the plutons. Depositional ages were very close to youngest zircon ages, because plutons were being unroofed soon after emplacement. After 770 Ma, there were several further surges to 80% or higher. After 830 Ma, Group MP and AP zircons almost disappear from the record. AP zircons re-appear in the Cryogenian as basins widened.

The ‘provenance’ of the sediments was constantly local, viz. the surrounding crust of the widening and deepening grabens. Zircon age-frequencies, however, were continually changing. Age-frequencies at any one time were similar from one basin to another not because sediment came from the same source but because the lithosphere region-wide was subject to the same episodic faulting and extension, driven by mantle upwelling. Likewise, to the extent that northern India, say, has a similar zircon record, this may be evidence that northern India was close to South China; it is not evidence that sediment was being transported across cratons.

TECTONIC EROSION AND SUBAQUEOUS WEATHERING: SOUTH CHINA IN THE MID NEOPROTEROZOIC

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With few exceptions, sedimentary basins started forming in South China's interior c. 860 Ma ago. Together these comprise the Nanhua Rift Basin, which was tectonically unstable until at least the end of the Cryogenian 635 Ma ago. Samples were taken from sequences in the second half of this interval, analysedfor major and trace element composition and evaluated for degree of weathering using the chemical index of alteration. Coverage particularly targeted (i) the transition across the Tonian– Cryogenian boundary, supposedly from warm to glacial, (ii) the transition into the Late Cryogenian warm interval and (iii) the transition into the second supposedly glacial interval near the end of the Cryogenian. Extreme swings in temperature are not evidenced. Weathering ranged from negligible to moderate or even strong, increased across the Tonian/ Cryogenian boundary, and was controlled primarily by tectonics.

Sedimentation was a function of rifting. There is no record of Neoproterozoic sedimentation outside the rift basins, and topography outside them appears to have been minimal. Sediment was generated by progressive widening and deepening of the basins as the crust thinned. Within them, successions typically attained thicknesses of several kilometres, mostly consisting of turbidites. Major and trace element analysis supports the view that deposits were essentially first-cycle, chemically and physically eroded from crystalline basement. Sediment was generated by faulting, shed from the sides of grabens and comminuted in the course of transport and reworking. Subaerial exposure is therefore likely to have been minimal. Weathering must have taken place after burial in the interval between deposition and maximum compaction. It cannot be regarded as a direct proxy for climate.

In common with the vast majority of Proterozoic siliciclastic sediments, weathering trajectories show loss of Ca and Na and gain of K. This is not an indication of ubiquitous 'K metasomatism' through the Proterozoic but of plagioclase dissolving in preference to K-feldspar. This pattern may indeed be characteristic of subaqueous weathering – especially where pH is affected by high pCO_2 and marine/subaqueous weathering may have been characteristic of the Proterozoic. In an analysis of 20 Palaeoproterozoic and Neoproterozoic formations, no overall difference in CIA was found between the 10 considered glacial in origin and the 10 considered non-glacial.

OLIGO-MIOCENE LACUSTRINE MICROBIAL-METAZOAN BUILDUPS FROM THE LIMAGNE BASIN (FRENCH MASSIF CENTRAL)

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The Limagne Basin is a continental lacustrine system accommodating extensive and spectacular microbial-metazoan buildups from the Chattian to the Aquitanian. A detailed characterization of these microbial-rich carbonated buildups and their associated sediments in two quarries (Grand Gandaillat and Créchy) provides insights into their spatio-temporal distribution patterns. Themicrobial-metazoan buildups display a high diversity of fabrics and sizes. Five macrofabrics are identified and correspond to: flats, cauliflowers, domes, cones and coalescent columns; all of them mainly displaying a laminated mesofabric. Four microfabrics are proposed on the basis of the morphology of microbial structures; laminae, columns and filaments and a microbial association with insect's pupal cases (caddisflies). This morphological characterization is preferred to the classical but complex nomenclature of the Oligo-Miocene microbial/algae considering the importance of the diagenesis in the preservation of such microorganisms. The changes of distribution, morphology and size of the microbial-metazoan buildups through time led to propose two depositional models, the first for the Chattian deposits in Grand Gandaillat and the second for Aquitanian deposits in Créchy, despite both systems emplaced along a low-gradient margin. This study emphasizes the heterogeneity of marginal lacustrine cycles given the high sensitivity of lakes to environmental changes. The Limagne Basin records several lacustrine/palustrine cycles at different scales. The lacustrine deposits of these cycles are composed of microbial-dominated buildups and organic matter-rich marls testifying humid conditions of the lake, while the palustrine deposits are composed of mudstone and greenish-grey clayey palaeosols which indicate periods of greater aridity. These alternating humid-arid conditions are traditionally attributed to a climatic control. However, the cycles differ at the Oligo-Miocene transition, with the thin and symmetrical cycles distinctive of the Chattian becoming thicker and asymmetrical during the Aquitanian. The Aquitanian deposits are marked by the development of microbial-metazoan buildups that are several meters high. In contrast, microbial buildups of the Chattian are merely centmeters thick, suggesting changes in accommodation. While the humid-arid conditions can be driven by a climatic control, these difference in symmetry and thickness between the Chattian and Aquitanian cycles can rather be linked to a particular paleogeographic context marked by a migration toward the north of the depocentres at the Oligo-Miocene boundary. The non-random distribution of microbial-metazoan buildups specifically along the fault corridors and the asymmetry of the cycles are related to the active tectonic and volcanic context of this Limagne region. Finally, the Chattian and the Aquitanian carbonate-siliciclastic ratio are different in the humid phase. This difference highlight the successive chemical weathering of palustrine carbonate following by and physical weathering of palustrine marls related to vegetation and topography of lake margins. Thus, the detailed study of microbial-metazoan buildups highlights a superimposition of the regional controlling factors (climatic, tectonovolcanism) and the local factors (chemical and physical weathering, vegetation cover and physiography of the lake margins). They have the potential to bring further insights into the reconstruction of paleoenvironments and paleoclimatic changes through time.

CONTROLS ON THE GEOCHEMISTRY OF SOUTH AMERICAN EQUATORIAL SUSPENDED SEDIMENTS (AMAZON, ORINOCO AND MARONI RIVERS)

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The tropical/equatorial part of South America hosts two major rivers in terms of dissolved and solid fluxes exported to the ocean: the Amazon and the Orinoco rivers. The Amazon River ranks first in terms of global mass transfer from the continents to the ocean, while the Orinoco River is the world's third-largest in terms of water discharge. The South American equatorial margin receives sediment inputs from the Orinoco and the Amazon river systems, which both drain the Andes, an extensive floodplain and old Precambrian terranes, but also from rivers that drain exclusively cratonic areas, such as the Maroni. Recent studies have demonstrated that hydrodynamic sorting of particles controls the geochemistry of the Amazon Suspended Particulate Matter (SPM). In addition, the Sr isotopic composition of SPM from the Madeira and Solimoes, two large tributaries of the Amazon River, varies throughout the hydrological cycle during the year. But it remains unclear whether hydrological processes also control the geochemistry of the SPM transported by the Amazon River and other tropical/equatorial south american rivers. This study reports Sr-Nd isotopic compositions and elemental concentrations (major and trace elements) of monthly-collected SPM from the Amazon, the Orinoco and the Maroni rivers during a one-year long hydrological cycle. We show that i) the Maroni, Orinoco and Amazon have distinctive mineralogical, Al/Si, CIA values, trace element ratios and Sr-Nd isotopic compositions (with respective averaged $\epsilon Nd_{(0)}$ and 2sd deviation values of -10.6±1.1, -14.1±0.5 and -23.7±2.,4) that mainly reflect source heterogeneities; ii) the CIA values and Sr isotopic composition of the Amazon SPM are correlated with corresponding SPM concentrations indicating that they are controlled by the hydrological cycle, and iii) the Nd isotopic compositions of the Amazon SPM ($\epsilon Nd_{(0)}$ -10.6±1) also co-vary with concentrations suggesting that they are also linked with the hydrological cycle. Our findings have implications on the application of Sr and Nd isotopes as provenance proxies in sedimentary rocks. First, the Sr isotopic composition of clastic sedimentary rocks appears to be mostly indicative of weathering processes rather than sediment provenance. Second, Nd isotopic variations lesser than1 ϵNd unit in sedimentary rocks may be used with caution for interpreting provenance change in big rivers as they might be related with hydrological seasonal variations rather than change in the sources of the sediments.

PROVENANCE RECORD OF MAASTRICHTIAN-PALEOCENE ANDEAN MOUNTAIN BUILDING IN THE AMAZONIAN RETROARC FORELAND BASIN (HUALLAGA AND MADRE DE DIOS BASIN, PERU)

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Dating the onset of the early Andean Mountain building and the coeval formation of the adjacent Amazonia retro-arc foreland basin are among the most controversial problems in Andean geology. One way to constrain the timing of orogeny growth is to date the first arrival of orogenic-derived detritus in the sedimentary record of the adjacent foreland basin. Hence, dating the shift in provenance from a cratonic to an orogenic source in the Amazonia foreland basin sedimentary record is of particular interest for determining the timing of the onset of Andean building. New biostratigraphy, sedimentology and provenance analyses (U-Pb dating on zircon and Sr-Nd isotopic composition) suggest that a proto-Andean Cordillera already existed in Northern and Southern Peru by Paleocene times. In the Huallaga basin (northern Peru), the Campanian-Maastrichtian sedimentary rocks (Chonta Formation) have low $\epsilon Nd_{(0)}$ values (-16 to -18) and by U-Pb detrital zircon ages with main peaks at at 1.82 Ga (36%), 1.54-1.8 Ga (25%) and 1.3-1.54 Ga (15%) and no zircon grain ages younger than 600 Ma. In the Madre de Dios basin, Early Maastrichtian sedimentary rocks have also low $\epsilon Nd_{(0)}$ values (-15 to -16) and they are characterized by Precambrian-inherited zircon grains. These provenance data suggest the existence of a cratonic drainage system by Early Campanian-Maastrichtian times probably sourced by the Central Brazilian shield. $\epsilon Nd_{(0)}$ values of ~-10 associated with the first appearance of zircon aged population younger than 120 Ma (14%) suggest an Andean source for the Early Paleocene to Eocene deposits of the Huallaga basin. Estuarine to shallow marine Late Paleocene deposits of the Madre de dios basin have also an Andean dominant source as attested by relatively high $\epsilon Nd_{(0)}$ values (-6 to -10) and by the presence of Paleozoic and Late Cretaceous zircon grains. These shifts in provenance are consistent with a Paleocene Andean building. In agreement with recently published studies, our data suggest that a significant proto-Andean Cordillera, extending from 41°s to 10°N, existed by the Paleocene epoch.

LARGE PIPES IN THE NORWEGIAN CENTRAL NORTH SEA REVEAL FLUID BYPASS THROUGH EARLY MESOZOIC SUCCESSIONS

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Large pipes are revealed by 3D seismic data within the Mesozoic succession on the Jæren High, in the Norwegian Central North Sea. High-resolution seismic mapping, combined with semi-automated mapping methods in ArcGIS, were used to analyse the morphology and distribution of pockmarks. Borehole and geochemical data were incorporated into Petromod to model the burial and thermal history, and to determine the timings of fluid expulsion from source rocks. Spatial analysis shows clear clustering of pipes and pockmarks directly above grounded Triassic pods, corresponding to salt welds. The pipes terminate with depressions within the Cretaceous marls and chalk.

It is proposed that gas matured from the Carboniferous coal source rock in the Norwegian sector, migrated up dip laterally and vertically into the Rotliegend sandstone reservoir, which was trapped by the Zechstein salt, in a similar way to many gas fields in the Southern North Sea. Once the Triassic sediment pods were grounded on the salt to form salt welds, a seal breach pathway was created, through which gas was expelled in vertically focused pipes, during the Upper Cretaceous period. According to this hypothesis, it is likely that much of the gas escaped on the palaeo-seafloor. However, seismic attribute analysis revealed abundant amplitude anomalies within the Triassic pods, which do not connect to shallower pockmarks. We propose that these anomalies represent gas pockets within sand bodies, trapped in the mudstone succession.

This study shows how analysis of new, higher quality 3D seismic data in a mature basin may reveal new exploration targets and prolong the life of the North Sea Basin, particularly when investigating relatively underexplored regions such as the Jæren High.

SOURCE-TO-SINK ANALYSIS IN RIFT BASIN: EXAMPLE FROM THE GULF OF SUEZ (EGYPT)

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The source-to-Sink (S2S) approach integrates (1) erosion, (2) transport and (3) deposition as one dynamically linked system. A major challenge of S2S analysis is to understand controls, interactions, coupling and feedbacks between these three sub-systems. Dataset necessary to constrain the different steps of the analysis are also challenging to gather, as well as the tools and concepts to be used. An overall characterization (sedimentary thicknesses, Environment of Deposition, relative timing of sedimentation versus faulting, fault pattern...) of the sedimentary basin and good age constrains. The pre-deformation configuration (initial topography, type and nature of catchments) is also a major challenge to address. Hereafter, we propose an integrated study of the Suez rift and a workflow to address the main S2S feedbacks in rift systems.

This work is based on a high-resolution basin-scale (~300 x 100km) database of the sedimentary fill of the Gulf of Suez (Egypt) using outcrop and subsurface data (279 wells and 31 sedimentological sections). The stratigraphic architecture shows five main stages of evolution, from rift initiation to tectonic quiescence (Oligo-Miocene) plus a post-rift stage (Plio-Quaternary). We first established a relationship between catchment and sediment supply during most recent history of the rift (Quaternary). We then carried a sedimentary budget analysis for the entire rift basin fill and discuss erosion and transfer dynamics during the rift evolution.

We show that the sediment supply dynamic in this rift basin is consistent with analog and numerical modeling prediction for tectonically driven evolution (growth, optimum, and destruction phases). Post-rift dynamic, and especially the flank retreat issue, has to be integrated into wider geodynamic consideration in this example.

We propose a geological scenario including quantified sediment supply and accumulation rate, lithologic distribution, and subsidence dynamics that can now be used to test modeling approaches of the relationship between lithospheric and surface processes, as well as better understand other rift systems.

RESERVOIR QUALITY OF TURBIDITE SANDSTONES: LESSONS LEARNED FROM PETROGRAPHIC ANALYSES AND FACIES CLASSIFICATION OF OUTCROP SAMPLES TAKEN FROM PROXIMAL IMMATURE CHANNEL FILLS TO DISTAL LOBES

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Reservoir quality and performance is a critical risk for deepwater projects. Discovery of hydrocarbon bearing turbidite sandstones can be considered as a real exploration success only if good to excellent reservoir characteristics are proven to ensure deliverability of large volumes during production. Mapping of reservoirs in deepwater depositional sediments is quite well constrained by 3D seismic cubes providing commonly excellent images of the depositional systems unless salt tectonics or compressional episodes have modified the architecture and eventually complicated the ray-path during seismic acquisition. Nevertheless, prediction of reservoir quality of turbidite reservoirs remains a challenging issue for explorationists as none of the classical exploration tools does provide a strong input to reduce risk during prospect analysis. Indirect methods such as the size of the capture area for the sediment, the type of rocks which were submitted to erosion in the hinterland and transported to the basin, and the gradient of the shelf can drive the prediction towards either one of the two end-members: rather immature coarse-grained depositional systems or rather mature fine-grained depositional systems.

The study of depositional facies tracts along the depositional profile in the well-studied South Pyrenean Basin in Northern Spain was launched aiming a detailed and careful sampling of immature coarse-grained channel fills in Ainsa Basin, to thick-bedded mature lobe sandstones in the distal lobes in Jaca Basin. The results of the present study validate the facies tracts model with a progressive decrease down-current of grain size and the flow processes interpreted from the facies description such as matrix type, grain roundness, sorting and grain type. The main features that can be identified are: (a) feldspar and plutonic rock fragments are more abundant in the proximal part of the system, (b) the finer, the more carbonate-rich, less quartz and rock fragments, and (c) grains deposited in proximal setting (channel fills) are more angular than those deposited in distal (lobes). Moreover, a strong increase down-current of the carbonate grains to the expense of siliciclastic grains is displayed at both basin and facies scale. Carbonate grains in the proximal Ainsa Basin are dominated by carbonates allochems with chambers whilst they consist mainly of platy grains in the distal Jaca Basin.

The relationship between poroperms (Porosity and Permeability) and depositional facies – prior to diagenesis – is quite clear resulting from depositional texture due to sorting that controls grain size segregation. Subsequently strong diagenesis downgrades porosity and particularly permeability as a result of feldspar dissolution and related precipitation of authigenic clays. The study undertaken has brought some insight to reservoir quality estimation and can be applied for predicting reservoir quality along depositional dip and reducing reservoir risk of turbidite reservoirs.

FORELAND BASIN EMERSION AND CANNIBALIZATION: A CASE STUDY OF INTEGRATED SANDSTONE PETROGRAPHY AND DETRITAL ZIRCON GEOCHRONOLOGY IN THE JACA BASIN (MIDDLE EOCENE-MIOCENE, SOUTH PYRENEAN BASIN)

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Characterization of the sediment routing evolution during continentalization of basins gives insights on the tectonic and erosional history of the source areas. The Eocene to Miocene clastic systems of the South Pyrenean basin are a good natural laboratory to investigate paleoenvironment, source areas and sediment composition changes during the progressive evolution of a foreland basin. We provide new petrographic and detrital zircon (DZ) U-Pb data of the northern Jaca basin in the Southern Pyrenees, whose stratigraphic evolution from Lutetian deep-marine to Miocene alluvial systems records a major tectonic and drainage reorganization in the active Pyrenean pro-wedge. The analyzed succession starts with the Bergua turbidite systems and the Jaca turbidite systems (Lutetian-Bartonian), whose uppermost system, the Rapitán turbidite system, records the last stage of turbidite sedimentation and its replacement by deltas. The Sabiñánigo Sandstone and Atarés deltas (Bartonian-Priabonian) represent the transition to the alluvial fan deposits known as Santa Orosia, Canciás, Peña Oroel and San Juan de la Peña fans (Priabonian-Early Miocene). The replacement of the deep-marine turbiditic sedimentation by terrestrial environments is accompanied by shifts in the location of the source areas, which were strongly controlled by the uplift of the Lakora/Eaux-Chaudes and Gavarnie thrust sheets in the hinterland. Detrital zircon geochronology results show a clearly different signature between the Hecho Group turbidites and the alluvial fans which can be associated to a major change in the source area. This change consists on a decrease of the variscan-aged population, which can be associated with the replacement of the axially-fed sediments derived from eastern sources, by transversely-fed sediments derived from new uplifted northern sources.

Coupling of DZ U-Pb data with petrographic analysis allows a better resolution of the source area shifts and a better discrimination between first-cycle zircon derived from Paleozoic plutonic rocks and multi-cycle zircon derived from the erosion of intermediate reservoirs (Mesozoic and Cenozoic). In addition, this coupling possibilities the distinction of major tectono-stratigraphic cyclicity in the analysed succession, displayed by the increase-decrease trends of the detrital zircon and rock fragment populations.

As the Upper Eocene-Early Miocene alluvial systems of the Jaca basin were fed from the erosion of the older Hecho Group foredeep turbidites, our study provides valuable insights on the response and propagation of detrital zircon U-Pb signatures during the recycling (cannibalization) of sediment within the basin.

INTERPLAY OF MULTIPLE SEDIMENT SOURCES IN THE SOUTH-CENTRAL PYRENEAN BASIN (LATE CRETACEOUS-EARLY EOCENE): THE ROLE OF THE EBRO MASSIF AS A SOURCE AREA

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The south-central Pyrenean Basin constitutes a good example to tie the changes in sediment routing and composition during the evolution of the basin. The Pyrenees is an inverted Alpine chain that developeddiachronously, from east to west. Characterization of sediment provenance in the south central Pyrenees is a challenging issue as the complex tectonic setting and the interference of various systems during the filling of the basin hinder it. In addition, the lack of agreement about the correlation between systems get in the way to achieve a well-constrained plaeogeographic reconstruction. A detailed petrological study leads to identify the compositional changes of the clastic systems and therefore to better understand the evolution of the sediment sources throughout the development of the foreland basin. During Late Cretaceous to Early Eocene the Àger and Tremp basins contained deltaic and fluvial deposits that evolved to the distal time equivalents of the Ainsa-Jaca basins. Our provenance results show that the clastic systems from both Àger and Tremp basins were derived from different source areas in different times. These changes can be identified in the Garumnian facies (Late Cretaceous), which in the Tremp basin show sediment input from new uplifted sources, located to the north (i.e. Sant Corneli-Bóixols anticline). In contrast, the Garumnian deposits of the Àger basin show distinct compositional features that imply a different source, located to the south. According to the petrological composition, we find the Ebro Massif as the most likely source area for these sediments. This source area was delivering a mature detritus to the south-central Pyrenean basin at least since Santonian times. In the Àger basin, supply from the Ebro Massif can be also identified in the Eocene deltaic and fluvial systems, having implications in the final composition of the distal deposits of the Ainsa-Jaca basin. Although the Ebro Massif acted as source area only episodically during specific intervals of the basin evolution, its clear provenance signature emphasizes an important role of the cratonic margin of the South Pyrenean foreland basin which has been overlooked up to date.

PETROPHYSICAL CHARACTERIZATION OF TUFA MOUNDS AND THEIR RELATION TO ACOUSTIC PROPERTIES, POROSITY AND PORE TYPES (ISONA TUFA MOUND COMPLEX, SPAIN)

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Reservoir heterogeneity in continental carbonates is complex, due to large variations in depositional fabric and petrophysical properties, including total porosity (e.g. differences in pore type or degree of cementation), and/or permeability. These changes create contrasts in seismic and electromagnetic wave velocities across localized areas. Recent studies in continental carbonate reservoirs in Brazil and Angola underline the importance of understanding the controls on petrophysics in such reservoirs, including tufas and travertines. However, few studies have incorporated non-invasive methods that use contrasts in seismic or electromagnetic wave velocities to infer changes in porosity and permeability.

This study builds on previous surveys in a Holocene tufa outcrop in the Tremp Basin (Spain) and combines thin section petrography, and lab-based porosity, permeability and seismic and electromagnetic wave velocity measurements to understand heterogeneity. Measurements were combined with rock elastic properties to build a velocity model that shows a clear correlation between tufa porosity and velocity.

Mounds consist of central vents and pools, which are separated from the surrounding slope and cascade facies by a distinct rim. Petrography varies between peloidal grainstones and thrombolites in vent and rim facies, to crystalline bryophyte shrub facies on the slopes and cascades of all mounds, as well as in the rims of younger mounds. Intercrystalline, intergranular, growth framework and vuggy pores are the dominant pore types. Cementation increases with the age of the mound.

The results showed heterogeneous buildups with porosities ranging from 18-46%, permeability typically in excess of 1 D, and P-wave (Vp) velocities of 6197-2055 m/s within a single mound. This corresponds to electromagnetic wave velocities between 0.110 m/ns in old vent facies and 0.092-0.094 m/ ns in young slope and cascade facies. Taking into account the poorer cementation in the studied example relative to other travertines, values are comparable to previous studies on travertines with Vp of 5363-3695 m/s. The primary controls on heterogeneity are pore types, connectivity, and degree of cementation. Better cementation in grainstones and thrombolites has reduced connectivity through the dominantly intercrystalline and intergranular pore network, resulting in low porosity and high Vp. In shrubs, a distinct anisotropic development of framework, large vuggy and intercrystalline porosity provides high connectivity parallel to shrubs. This fabric is also less cemented, contributing to its high porosity and low Vp. These carbonates are potentially very prospective with high volumes of hydrocarbons-in-place. However the weak mechanical strength and low pore collapse pressures could result in high production costs unless the carbonates are more cemented.

MULTI-PROXY PROVENANCE ANALYSIS ALONG THE MOROCCAN ATLANTIC MARGIN: TRACING SOURCE AREAS FOR LOWER CRETACEOUS RESERVOIRS IN THE ESSAOUIRA-AGADIR BASIN (EAB)

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Deciphering the shallow-marine to fluvial transition zone in deep time along continental margins is key in unlocking the potential of Source-to-Sink studies. This provides vital information on the distribution of reservoir sandstones. The Mesozoic basins along the Moroccan Atlantic margin combine outstanding outcrops and continuous Triassic to Late Cretaceous stratigraphy. The Early Cretaceous shallow marine to fluvial coarse clastic successions are an exploration target offshore, but limited successful drillings reflect the poor understanding of the depositional systems and its links to the eroding hinterland. This highlights the need of a more holistic approach, tracing sediment routing and the main input points through time.

Middle Jurassic to Early Cretaceous tectonic movements have controlled subsidence within the basins, erosion of the provenance terrains and let to conditioning of the delivery system. This in turn has influenced the location and timing of sandstones deposition during the Jurassic and Cretaceous.

This integrated regional analysis aims to: (i) develop a robust regional palaeogeography and tectonostratigraphic model highlighting the evolution from source to sink, (ii) understand the controls, timing and volume of the sediment supply to the margin delivered via fluvial systems and (iii) constrain the importance of sediment recycling, mixing and storage, and how they are influenced by the tectonostratigraphic evolution of the margin. A specific question is whether differential uplift in the hinterland resulted in a change of sediment sources and reorganization of sediment routing across the margin. This project applies sandstones petrography and geochemistry (including detrital feldspar and zircon geochronology) to trace sandstones provenance and to establish a source-to-Sink model for the Mesozoic succession.

Preliminary results shows diagnostic age trends in each of the potential source massifs: (a) Hercynian ages in the Northern massifs (Meseta), (b) mixed Pan-African and Hercynian ages in the High Atlas and (c) Panafrican magmatism associated with Palaeoproterozoic granites in the Anti-Atlas. The distinct age signature should be recorded in detrital zircon populations and thus enable the testing of the model predicting Jurassic provenance mainly from the south (Anti Atlas, potentially Reguibat Shield), followed by Cretaceous provenance mainly from the east/northeast (Meseta, Massif Ancien de Marrakech). Petrographic work on the Barremian to early Aptian clastic succession of the EAB has already identified potentially distinct clast populations with volcanoclastics likely derived from ignimbrites or Central Atlantic Magmatic Province (CAMP) basalts of the Anti-Atlas and High-Atlas. Intrabasinal derived material is also recognised, revealed by the existence of carbonate clasts, likely from Jurassic or Cretaceous formations.

Ongoing and future work is focused on constraining the observed trends in the Early Cretaceous sandstones through dating of the detrital zircons and feldspars and petrographic statistical study.

GEOCHRONOLOGY AND MORPHOSTRATIGRAPHIC ANALYSIS OF AN INTRAMONTANE DEPOCENTER AND ITS IMPLICATION IN TIMING AND PROCESSES OF THE CENOZOIC EVOLUTION OF THE CHILEAN FRONTAL CORDILLERA

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The Chilean Frontal Cordillera, near 28°45'S, provides a remarkable example to explore the evolution of the Central Andes; in this area conspicuous pediment relicts and continental deposits are preserved, which allowed us to analyze the timing and propagation of defor-mation which controlled the Andes building, and constrain the erosion and denudation of the Andes during the Cenozoic, using structural, geomorphological, sedimentological, stratigraphic and geochronological data.

The study area is characterized by outcrops of the Cerro del Burro Gravels, a continental deposit, surrounded by four morphostructural mountain systems. Based on a 46 Ma tuff affected by a syncline, which is sealed by a 44 Ma tuff, we recognized Eocene fault activity that contributed to the uplift of the western and northern systems. This fault system has remained inactive during the last 44 Ma.

The deformed lithologies during the last pulse of activity of the western fault and the youngest lithology carved (21 Ma) indicate a pediment surface development between Late Eocene and Oligocene. This pediment extended widely to the east, including the area presently covered by the Cerro del Burro Gravels, associated to a base level which drained to the east.

We also recognized Miocene fault activity that played a main role in the uplift of the eastern and southern systems. Geochronological, stratigraphic and geomorphological data suggest a first pulse of fault activity between 19 and 13 Ma, which interrupted the pedimentation processes, developed an intramontane depocenter, and forced the accumulation of the Laguna Grande Succession. This unit is composed for a succession of stratified, clast-supported and unsorted gravels showing subrounded to sub-angular clasts. Subordinately, matrix-supported unsorted gravels are intercalated within the clastsupported facies, and massive decametric tabular and lenticular shaped beds, with erosional bases of medium to coarse sands. The unit also contains minor centimetric intercalations of silt and mud with occasional desiccation cracks, and discrete levels of carbonate indurated strata within the sandy matrix of gravels. Some variations are observed from the base to the top: in the basal part predominates the clast-supported gravels, with blocks that reaches up to 0.8 m, whereas in the upper part the clastsupported gravels are more abundant. To the east we observed exclusively matrix-supported gravels inter-fingered with a few thinner lenticular sands and clast-supported medium gravels. In this area, the diameter of the blocks reaches up to 1.2 m. In addition, more subangulous clasts are observed in this zone, as well as brownish less dense and disaggregated beds, which were not present in the other outcrops. These series are inferred to represent clastic rich debris flow deposits, in an alluvial environment, intercalated with an braided fluvial environment, with occasional overbank and paleosols revealing periods of relative stability and hiatus in the deposition.

After 13 Ma, an erosive event is evidenced by the incision of the current valleys linked to a base level which drains to the west. This change is associated to the westward capture of the intramontane basin following 13 Ma, and the increase of relief and area of basins.

A LATE HOLOCENE SEISMITE IN SOUTHERN AMAZONIAN LOWLANDS, BRAZIL

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Morphostructural evidence of tectonic reactivation in a relatively recent geological time is now available from many areas of Amazonian lowlands, but the sedimentary imprint of such phenomenon remains undocumented. In this work, we provide sedimentological descriptions of a 1.5 m-thick deformed interval having various styles of soft-sediment deformation structures within a late Holocene fluvial succession at the right margin of a main southern Amazonian tributary. We combine this information with qualitative and quantitative morphostructural data to defend that the soft-sediment deformation bed is a seismite formed by the propagation of seismic waves on the ground during fault reactivation. The interval of seismite formed within a channel environment and it records mostly convolute folds, flames and overloading structures, which are intercepted by numerous small-scale, normal graded faults with composite, NW-SE trending planes that end up with depth. There is a vast literature linking similar structures to various sedimentary processes inherent to the fluvial environment, mostly including active river-bank erosion, differential loading, gravity slides and current shear. However, an origin related to a tectonically-triggered seismite is more likely in this instance considering that solely processes intrinsic to channel dynamics could not justify the abundant graded faults verified in association with the ductile sedimentary structures. This interpretation is also supported by the fact that these faults have trends similar to numerous straight lineaments extracted from this region and also to the main tectonic structures documented over the Amazonian lowlands. The seismite is located in a region having numerous morphostructural anomalies (i.e., trellis and sub-trellis drainage; rectangular and, to a less extent, annular channels; anomalously enlarged channels; orthogonal channels and valleys; channel captures; sudden changes in channel morphology; moderate to high basin asymmetry factor (AF between 9.8-27); moderate to high transverse topography symmetry factor (T= 0.31-0.49); and anomalous longitudinal river profiles, with concavity values (11.12 to 29.91%) indicative of rivers in process of adjustments. In addition, the composite fault planes are indicated as potentially diagnostic of seismites, as they are related to successive short episodes of faulting alternated with sediment deposition due to the propagation of seismic waves even in a daily-time scale basis due to aftershocks. Thus, this work represents the first sedimentary record of a seismite in Amazonian lowlands, evidencing fluvial deposition influenced by the impact of earthquakes in the last few hundred years ago.

NEW PLAY CONCEPTS ASSOCIATED TO SUBMARINE UNCONFORMITIES DEVELOPED ALONG HINGED MARGINS: LESSONS LEARNED FROM OUTCROPS AND SEISMICS

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Submarine erosional surfaces in shallow water, shelfal and slope settings are examined to explore their potential for producing stratigraphic or mixed traps. New play concepts are considered, derived by outcrops traced in their buried counterparts using seismic profiles or converted into synthetic seismic volumes. Subsequently this information is used as analogue for the identification and characterization of new plays worldwide, with particular regard to syntectonic margins developed in both mature areas and frontier basins.

Attention is focused on erosional surfaces developed along hinged margins undergoing increasing rates of tectonic accommodation. This often results in the development of unconformities traced for hundreds of km, generated by the tilting and destabilization of coastal wedges due to abrupt and high magnitude accommodation increase. This may be recorded by the enhancement of ravinement surfaces on the shelf, while gullies or canyons and retrogressive slump scars extend from collapsed shelfedges into oversteepened ramps.

These unconformities typically develop in foreland basins, strike slip basins and marine rift basins that may often experience rapidly increasing and laterally changing subsidence rates. Deepening-upward intermontane basins and intra-slope basins are the most typical morphostructural settings in which these features tend to develop. The outcrop examples derive from the Tertiary Piedmont Basin lying over the AlpsApennines Junction in NW-Italy, and the Mesozoic Basque-Cantabrian Basin recording the opening of the Bay of Biscay in NW-Spain.

As opposed to the classical sequence boundaries driven by relative sea-level falls, these hingedmargin unconformities result in the drowning of shallow marine systems abruptly onlapped by deeper water facies and pass laterally into paraconformities associated to large stratigraphic lacunae of regional extent, driven by basin reorganization and reshaping. While the drowning of carbonate platforms often occurs for ecological reasons, perhaps not surprisingly in tectonically active margins a basinward tilting may produce as well the drowning of clastic shelves, which in such a case shows evident angular unconformities instead of the omission surfaces more typical of the classical drowning unconformities affecting some carbonate systems.

Five main types of play concepts are identified: (1) tilted deltaic remnants left by multiple retrogressive slump scars or submarine canyons; (2) high accommodation-high sediment supply turbidites sourced from the collapsed and eroded portions of these deltas; (3) drowned basement highs onlapped by fan deltas abruptly overlain by deeper-water mudstones; (4) faulted margins onlapped by turbidite wedges; (5) diapir flanks affected by progressive unconformities during their growth.

The outcrop examples are compared to similar seismic examples in basins with variable geodynamic settings and structural styles, highlighting the difference between unhinged conventional sequence stratigraphic models and hinged-margin unconformities. It appears that in these cases a model-independent and more flexible sequence stratigraphic approach is required, combined with the analysis of the morphostructural reshaping of basin margins and the associated change in fairways and depositional processes.

IMPACT OF TIDAL CURRENTS ON DELTAIC MORPHOLOGY, STRATIGRAPHIC ARCHITECTURE AND SEDIMENT PARTITIONING

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Deltas are dynamic and sensitive systems that undergo changes of morphology, channel network, and stratigraphic architecture in response to variations in coastal processes, e.g., waves and tides. These changes need to be properly understood in order to properly understand delta evolution and to make reliable subsurface predictions.

Numerical modeling has been extensively used to study delta evolution in response to a single dominant coastal forcing, but rarely to examine the sensitivity of delta that reflects mixed energy environments. Therefore predictions on reservoir modeling based on such models could be highly misleading when used in mixed-energy delta systems, where fluvial floods are largely reworked by laterally varying waves and/ or tidal processes. This study uses Delft3D to investigate the influence of tidal currents on river-dominated deltas in terms of deltaic stratigraphic architecture and sediment partitioning. We conducted 24 modeling runs with different ranges of tidal amplitude and initial sediment composition of the substrate.

The modeling results show that deltas formed under pure river-dominated conditions have a concave delta-front profile while with increasing tidal amplitude the delta front becomes convex and develops a compound clinoform geometry. With no tidal currents, distributary channels avulse and bifurcate frequently, resulting in the complete reworking of deltaic lobes. As a result, coarse sediment is stored in the proximal delta plain. In contrast, the presence of strong tidal currents creates deeper and stable distributary channels. These channels do not rework previously deposited deltaic lobes, but act as an efficient conduit for sediment to bypass across the delta during ebb currents. Furthermore, the analysis of sediment fluxes across the delta shows that ebb tidal currents increase suspended and bedload sediment fluxes by at least 3 times compared to cases without tidal currents. The enhanced sediment flux leads to deposits with net-to-gross ratios higher in tidally influenced cases than in their river-dominated counterparts.

This study shows how tidal currents, even under river-dominated conditions, have strong effects on delta surface morphology, stratigraphic architecture, and sediment partitioning. A proper understanding of how deltaic systems respond to varying coastal processes is of paramount importance, not only for their subsurface characterization, but also to predict their evolution during rising sea level.

INTERPLAY OF TIDAL AND FLUVIAL PROCESSES ALONG THE EARLY PLEISTOCENE SIDERNO PALEOSTRAIT MARGIN (CALABRIA, SOUTHERN ITALY)

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The sediments deposited within straits and seaways have been significantly understudied with respect to other depositional settings, even though many reservoirs in the North Sea and the Norwegian Continental Shelf are developed in narrow grabens or seaways with tidal currents. In particular, deltas impinging tide-dominated straits or seaways would be significantly affected by strong currents flowing parallel to the coastline, and capable of dispersing large volumes of sand for significant distances along the coast and along the strait axis.

In this study, we present a detailed sedimentological and stratigraphic analysis of an early Pleistocene marginal-marine succession deposited along the northern margin of the Siderno paleostrait (southern Italy). Here, deltaic systems fed large volumes of sand and gravel into the tide-dominated strait. Depositional patterns were impacted by the presence, along this margin, of an isolated tectonic high (Piano Fossati), which created a ca. 3.5 km-wide local passageway.

The field-based facies analysis documents an initial stage of non-tidal shallow-marine sedimentation across the strait. A subsequent sediment influx from the delta caused river-generated hyperpycnal flows and the transfer of large volumes of pebbly and shelly sandstones into slightly deeper water. Tidal currents became amplified in the strait, and, in the delta front area, they were able to rework river-derived sediments generating large dune fields. The strong tidal influence skewed the delta front (causing it to be strongly asymmetrical) and elongated sand bodies in a direction parallel to the marine strait axis. Coast-parallel deflection of delta-front deposits is a typical feature of deltas entering tide-dominated seaways and straits, and imposes signatures that differ from those in the classical tide-influenced deltas. This process became progressively enhanced during the following transgression, when tide-modulated currents reworked biocalcarenitic sands over the previous delta deposits, generating southeasterly migrating dunes. At the end of the transgression, strandplain progradation caused the closure of this marginal branch of the Siderno Stait.

This work provides new insights on sedimentation in a tide-dominated strait, and helps to predict sandbody distribution along the strait margin and axis. These findings can be applied to any other setting characterized by a narrow (possibly structurally-confined) basin dominated by tidal currents.

LATE PERMIAN TO LATE TRIASSIC PALEOGEOGRAPHIC EVOLUTION OF THE SOUTH CHINA AND INDOCHINA BLOCKS, SOUTH EAST ASIA

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The timing, spatial pattern and mechanisms that controlled the biotic recovery following the endPermian mass extinction, during the Early and Middle Triassic, are still under debate. In South East Asia (SEA), an Early Triassic biotic recovery has been documented in both terrestrial and marine ecosystems. SEA thus appears as a key area to document how life recovered after the end-Permian mass extinction. However, some aspects of the paleogeography and geodynamic evolution of SEA during the late Permian to the Late Triassic, those are likely to have influenced the biotic recovery in this area, remain debated. The debates concern, in particular, the formation of the Indosinian mountain belt that resulted from the continental collision between the South China and Indochina blocks, representing the main plates that composed SEA at that time.

Sedimentary basins, through the sedimentary successions and the nature of the deposits, reflect the geology of the area from which the sediments were derived and provide valuable record of hinterland tectonism. To document the building of the Indosinian mountain belt and associated paleoenvironments, we investigated two sedimentary basins: the Sam Nua and the Song Da basins (present-day northern Vietnam), located, respectively, to the south and to the north of the inner zones of the Indosinian orogen (i.e., the Nam Co and the Song Ma units). Using sedimentological and dating analyses (foraminifers biostratigraphy and U-Pb dating on detrital zircon), we provide a new stratigraphic framework for these basins and propose a geodynamic evolution of the present-day northern Vietnam.

During the late Permian to the Early Triassic, the Sam Nua Basin was opened to marine influences, and was mainly supplied by volcaniclastic sediments originating from an active volcanic activity. Geochemical investigations, combined with sedimentological and structural analyses, support an arcrelated setting for this magmatism, indicating the presence of a continental arc on the northern margin of the Indochina plate. During the Middle to the Late Triassic, the Sam Nua Basin underwent erosion that lead to the formation of a major unconformity resulting from the dismantling of the Indosinian Truong Son belt, built after the continental collision between the South China and the Indochina blocks. The sedimentation resumed at the end of the Late Triassic, with the deposition of very coarse material, emplaced under continental setting in a syn-to post-orogenic foreland basin. To the north, the Song Da Basin is characterized by strongly diachronous formations, deposited during the Early and the Middle Triassic over a basal unconformity. These formations correspond to marine platform limestone and continental deposits, and represent the infilling of a foreland basin. Together, the Song Da and Sam Nua basins thus document the geodynamic evolution and the paleogeography of SEA during the late Permian to the Late Triassic. The South China and the Indochina blocks were separated by an oceanic domain, that closed progressively until the Middle Triassic and resulted in the formation of the Indosinian mountain belt. These highly dynamic tectonic changes were associated with paleoenvironment variations that have likely impacted the biosphere turnover during the Triassic.

EARLY PALEOPROTEROZOIC UNCONFORMITY IN THE SOUTHERN SÃO FRANCISCO CRATON, BRAZIL: CLIMATE OR TECTONIC?

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The Quadrilátero Ferrífero, located in the southern part of the São Francisco Craton, Brazil, represents one of the most intensively studied Precambrian sedimentary archives of South America. The compilation of various chronostratigraphic constraints (i.e., U-Pb dating on carbonates and chemostratigraphic correlations) available for the Paleoproterozoic (2500 Ma and 1600 Ma) formations that were deposited in this area points toward the occurrence of a major early Paleoproterozoic unconformity, spanning from ca. 2420 Ma to ca. 2220 Ma. While this unconformity probably represents a major stratigraphic gap, its significance remains, up to now, elusive.

During the Paleoproterozoic, the Quadrilátero Ferrífero witnessed the collision between the nuclei of the São Francisco and the Congo cratons, corresponding to the extensive and long-lived Trans-amazonian (or Eburnean) orogeny. This orogeny involved the collision of various oceanic arcs and microcontinents that are yet incompletely characterized. Particularly, arc magmatism, interpreted to represent an oceanic arc, is documented as early as ca. 2350 Ma to the South of the Quadrilátero Ferrífero. The early Paleoproterozoic unconformity in the Quadrilátero Ferrífero could thus correspond to an early, yet unrecognized, Trans-amazonian tectono-magmatic event.

Alternatively, the early Paleoproterozoic unconformity of the Quadrilátero Ferrífero could be related to one or several of the major climatic changes that occurred during the Siderian and the Rhyacian periods. Indeed, glacial deposits have been reported in various cratons across the world, and three to four glacial periods, known as the Huronian glaciation events, occurred during this era. Because of the worldwide distribution of glacial deposits, at least one of the glacial events is suggested to correspond to a “Snow Ball Earth”, during which the whole Earth was capped by an ice sheet. However, up to now, no glacial deposits have been reported in the São Francisco Craton, and the peculiar lack of glacial deposits on this craton has been linked to a bias in the sedimentary record attributed to the early Paleoproterozoic unconformity documented in the Quadrilátero Ferrífero.

To distinguish between these two hypotheses, that are not mutually exclusive, we undertook multidisciplinary studies in the formations bracketing the unconformity. Using sedimentological analyses, we firstly characterized the depositional environments that prevailed before and after the formation of the unconformity, to determine if glacial environments occurred in the Quadrilátero Ferrífero. Secondly, we performed geochronological analyses (U-Pb on detrital zircon) on samples collected in the formations bracketing the unconformity to provide additional age constraints on the duration of the unconformity. Using petrographic information and age distributions obtained by U-Pb geochronology on detrital zircon grains, we then characterize the sources of these formations, in order to assess the tectonic setting and discuss the tectonic and/or climatic controls on the sedimentation patterns of the Quadrilátero Ferrífero in the Siderian and the Rhyacian.

NEOARCHEAN TO PALEOPROTEROZOIC GEODYNAMIC EVOLUTION OF THE QUADRILÁTERO FERRÍFERO, SÃO FRANCISCO CRATON, BRAZIL: A PERSPECTIVE FROM SEDIMENTARY ARCHIVES

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The Quadrilátero Ferrífero ("Iron Quadrangle") is a metallogenic district located in the southern part of the São Francisco Craton, eastern Brazil. This area comprises several sedimentary sequences that accumulated between the Neoarchean (ca. 2800 Ma) and the Paleoproterozoic (ca. 1700 Ma). Despite being one of the most intensively studied Precambrian sedimentary archive of South America, partly for its wealth of ore deposits (e.g., Banded Iron Formation, Au, Mg), the stratigraphic framework of the major sedimentary units that accumulated in the Quadrilátero Ferrífero remains debated. In particular, controversies surround the depositional ages, the paleoenvironments that prevailed during deposition, as well as the tectonic settings associated to the emplacement of some of the sedimentary units.

In recent years, a fairly large amount of detrital zircon ages has been acquired for most of the sedimentary units in the Quadrilátero Ferrífero, comprising more than 3300 concordant grains extracted from the Archean and Paleoprotezoic formations. A comprehensive compilation of existing and newly obtained U-Pb ages on detrital zircon grains, coupled with relevant chronostratigraphic constraints (e.g., emplacement age of metavolcanic layers, chemostratigraphic correlations) firstly allows us to better constrain the depositional ages of the main Neoarchean and Paleoproterozoic sedimentary units. This refined stratigraphic subdivision notably highlights the relative duration of the different stratigraphic gaps that occurred between depositional episodes, and reveal the unexpected importance of an early Paleoproterozoic unconformity.

Additionally, the U-Pb detrital zircon ages distribution allows us to assess the sources for the main sedimentary sequences identified in the Quadrilátero Ferrífero, which reflects the geology of the exhumed lithologies from which the detrital grains were derived. This allows: (i) to assess the geodynamic context in which the sedimentary sequences were deposited, and (ii) to infer the potential geodynamic events that lead to the formation of the main unconformities. The sedimentary archives of the Quadrilátero Ferrífero are shown to document the main geodynamic events that shaped this part of the South America shield. After the emplacement of a Greenstone Belt during the Neoarchean, the Quadrilátero Ferrífero experienced a rifting event at ca. 2550 Ma, and became a passive margin during the early Siderian (ca. 2500 to 2400 Ma). A major, early Paleoproterozoic (ca. 2400 to 2200 Ma), stratigraphic gap occurred later and possibly resulted from the major paleoenvironmental changes that characterize this era. During the middle Paleoproterozoic (ca. 2150 Ma) the Quadrilátero Ferrífero became a foreland basin of the Transamazonian orogen. A major unconformity, resulting from the erosion of this mountain belt, developed during the Orosirian period (ca. 2100 to ca. 1875 Ma). The sedimentation started again at the end of the Orosirian (ca. 1875 Ma) in the Quadrilátero Ferrífero, corresponding at that time to a late to post-orogenic foreland basin.

BIOSTALACTITES FROM PRESENT-DAY SUBMARINE CAVES OF THE MEDITERRANEAN

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Biostalactites hanging from ceilings and walls of submarine caves were first described from southeastern Sicily, Ionian Sea, Mediterranean and southern Apulia, southern Adriatic Sea. Recent investigation of caves from Lesvos, Aegean Sea and Cyprus, Levantine Sea, is revealing that these biogenic structures are rather common throughout the Eastern Mediterranean.

Hanging biostalactites are typically located from inner semi-dark to dark sites inside caves from about 9 to 40 m depth, and show different sizes and morphologies, as well as variations in surface roughness/ smoothness. Biostalactites consist of metazoan–microbialite associations. Serpulids of the genus Protula are the main constituents, but other serpulids as well as bryozoans, foraminifers and rare corals are also present. Microbial carbonates made up by autochthonous, peloidal to clotted peloidal and aphanitic micrite, contribute to strengthen bioconstructions. Micrites containing high bacterial lipid biomarkers, have been interpreted as produced by sulfate-reducing bacteria.

Investigation of the internal structure of the biostalactites from Sicily, showed the transition from a Protula core to an outer layer consisting predominantly of small serpulids, bryozoans and foraminifers, allowed to put forward hypotheses about inception of these bioconstructions along fractures of the cave ceiling and to trace the history of their development during the Holocene.

Location and mapping of biostalactites using a specially designed dive-operated laser-scanner 3D device has been suggested.

BRYOZOANS AND THEIR ROLE IN BIO-GEO INTERACTIONS: AN OVERVIEW FROM THE MEDITERRANEAN

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Bryozoans are colonial organisms including a wide array of encrusting skeletonised species, which live in a variety of benthic habitats from the coastline to the abyssal depths, all over the world. Owing to their carbonate (calcite, aragonite or bi-mineral) skeletons, they are usually preserved as fossils.

Bryozoans can develop millimetre-to decimetre-and even metre-sized colonies, whose remains contribute clasts to the formation of carbonate sediments, above all at mid latitudes. Furthermore, some species (especially if they attain large sizes and/or are gregarious) grow cementing on each other to form elevated biogenic structures.

These structures are relevant from a biological point of view because they create new physical and ecological spaces for other organisms, promoting local increase in biodiversity. These structures also produce changes in the general seascape, modifying the bottom texture and consistency in correspondence of the concretions, contributing coarse bioclasts to neighboring soft bottoms, and even to shape local hydrology.

Bryozoan build-ups are common features of present-day oceans and the Mediterranean Sea, where bryozoans are usually associated with other organisms, especially with non geniculate corallinae algae and serpulids, in the circalittoral zone along the shelf, to form the so-called "coralligène".

Bryozoan build-ups are usually located and investigated by scuba diving at shallower depths where the encrusting multilayered species Schizoporella errata forms metre-wide and decimetre-thick massive structures with prominent unilaminar funnel-like structures usually hosting barnacles, and the erect branched species Pentapora fascialis produces hemispherical to pillow-like widely opened structures. Deeper buildups, predominantly constructed by, or including, bryozoans, have been also discovered in the Tyrrhenian and Ibero-Provencal basins. These extensive bioconstructions, first described by Marion (1883) as "graviers coralligènes à grands bryozoaires", may reach one hundred metres in width and some decimetres in thickness. They largely consist of the erect branched species P. fascialis and Smittina cervicornis, and have possible fossil counterparts in Lower Pleistocene successions known from Sicily and southern Italy, consisting largely of these two species, often associated with Hornera frondiculata.

HOLOCENE STRATIGRAPHIC ARCHITECTURE AND CURRENT LAND SUBSIDENCE OF THE VOLTURNO COASTAL PLAIN (NORTHERN CAMPANIA, SOUTHERN ITALY)

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Aim of the present study is the assessment of the ground deformation trends referred to almost two decades (years 1992-2008), which characterize the alluvial plain of the Volturno river, located in northern Campania coastal area (Italy). The spatial analysis of the SAR data and stratigraphic architecture highlighted the major ground deformation occurring within the outer boundary of the incised paleo-valley, corresponding to the Holocene alluvial/transitional filling. Soil properties like compressibility, permeability, coefficients of primary and secondary consolidation, can greatly help in understanding the deformation process under observation and in quantifying the contribution to the overall rate of settlement of primary consolidation and creep.

BRIDGING THE GAP BETWEEN GILBERT-TYPE BOTTOMSET AND ASSOCIATED TURBIDITIC SYSTEMS: INSIGHTS FOR DEPOSITIONAL PROFILES IN HIGH SEDIMENT SUPPLY SETTING

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Gravity-driven processes produce turbiditic systems with an overall downslope direction. Slope, nature of the sea floor and bottom-currents are key parameters constraining the sediment transfer from the delta to the deep-sea fan. They are extensively described in the literature mainly from seismic and in less proportion from outcrop and modern data. Involved internal processes are also intensively studied by numerical modeling.

To bridge the gap between the marginal coarse-grained delta and the basin axis depocenter in highsediment supply, we propose to study outcrops of the Ilias Gilbert-type pro-delta along the southern margin of the gulf of Corinth in Greece. An entire sedimentological profile is documented from source-to-Sink based on standard field observations enhanced by 3D photogrammetric models (UAV acquisition), and with a focus on the facies distributions, the facies associations, the internal architectures and the morphologies.

The Gilbert-type delta bottomset reveals four bottomset-dynamics under specific processes integrated within a stratigraphic frame. During highstand normal regression, the gravelly bottomset mainly develops under subcritical flow. The supercritical flow undergoes a stationary hydraulic jump in the toeset due to the slope break and becomes subcritical. As a result, a "low-relief channel-levees" system is formed in the bottomset. The channels are reworked by backstepping conglomeratic lenses interbedded with silty concave-up and concave-down levees. During normal regression, the foreset beds are steeper and scoured in the upper part. In the bottomset, significant erosion recording sediment bypass downstream toward the prodelta. During lowstand normal regression, starved fine silt to shale bottomset onlaps onto the major erosional surface. During the transgressive stage, the topset and foreset are eroded by high-density turbidity currents and massive coarse-grained sandy turbidites are deposited in the bottomset, which onlap onto the foreset beds and form a slope apron geometry in the delta toe.

Down-stream of the Gilbert-type delta bottomsets, the sedimentary system is dominated by conglomeratic channels with an axis of 60° from the delta axis / fault controlled. The channels are limited by both external and internal levee with specific facies and architecture. They are commonly characterized by low sinuosity geometries. The external levee could locally include sediment waves.

This study provides the key elements to recognize the specific facies and architectures of the different bottomset typologies in relation with the associated turbiditic system. These sedimentary and stratigraphic models improve the prediction for the sand and conglomerate distribution and their connectivity within the various parts of the delta toe in a clastic depositional profile induces by a high-sediment discharge.

THE UPPER SURAKHANY FORMATION, A STRONG UPPER PLIOCENE DESICCATION PHASE COMPARED TO THE MESSINIAN SALINITY CRISIS IN SOUTHERN CASPIAN SEA

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The Messinian Salinity Crisis (MSC) affecting Mediterranean and Black Seas is also very well documented in Caspian Sea, where deeply incised subaerial valleys are well known such as this of the Volga River, however to date like in Black Sea any evaporites are reported in the deepest part of the basin at the base of Productive Series where normal deltaic or shallow marine sedimentation sharply rests over deep water shales. The reason of this lack is double; first because of tectonism, the sills (at least Bosphorus?) separating the different sub basins remind too high to temporarily allow the influx of saline waters and second because of the large scale catchment areas of the Volga and the Amu Daria rivers, large amount of fresh water influx do not permit to concentrate brines leading to evaporites precipitation.

But surprisingly, three main evaporite horizons including halite and anydrite occur at the base of the Upper Pliocene around 2.6 My, within the Upper Surakhany Fm. and immediately below the base Akchagyl marked flooding, where marine sediments come back.

Like in the messinian model, evaporites occur in the basin centre and they are onlapping against the marginal unconformity. By place fluvial incised valleys can be observed however they are not very deep. They tend to converge toward the salina located in the centre of the Southern part of the basin.

The salina itself includes salt and mainly anhydrites horizons interbedded with siliciclastics (sst, siltstones and shales). Three to four high frequency sequences can be recognized before the basal Akchagyl flooding, therefore we have to explain how this basin which was affected by the messinian drawndown without evaporites deposition could leads to evaporites deposition with a much smaller amplitude sea / lake level fall.

We can probably assume, most likely that a first marine reflooding from Black Sea occurs either in the Mid or in the Lower part of Upper Surakhany or at least at the time of the evaporites deposition (i.e. the lowstand) because of basin reconnection trough the sills separating Black Sea and Caspian Sea. These sills primary links to the Caucasus forebulges migrate and flexural subsidence allows marine flooding to enter. Then, high frequency sea level changes may occur in order to temporarily reduce Caspian Sea and Black Sea water exchanges. During these short periods brines are able to be developed in the basin centre; in the mean time that the basin margins are exposed and subject to subaerial erosion. The key question is to know how this is recorded in the Iranian side of the Caspian where very few data are available.

RAVINEMENT SURFACES AND EARLY TRANGRESSIVE DEPOSITS: KEY ELEMENTS OF STRATIGRAPHIC ANALYSIS OF TRANSGRESSIVE SYSTEM TRACTS EXAMPLES FROM THE MIOCENE OF SE FRANCE

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Trangressive Ravinement Surfaces (RS) have been reported since a long time. More recently they have been replaced in a consistent sequence stratigraphy framework. Basically they are often merged with the subaerial sequence boundary and transgressive surface. However in some cases they split in two the trangressive system tracts. At the base occur either paralic deposits or even lake deposits and above the surface we commonly found open marine deposits ranging from barrier complex, shoreface or open marine tidal sandbodies. Only detailed sedimentological study and datation as well as geometrical analysis allow discriminating if the paralic or lake deposits which are always very proximal represent the most regressive facies association of the high stand system tract or if they really belong to the base of the overlying transgressive system tracts.

The Miocene of SE France foreland basin provides multiple opportunities within numerous 3 order sequences to illustrate the variability of these early transgressive deposits and to illustrate the relative importance of R S. Because this SE France basin is part of the peri-alpine seaway, this narrow corridor is strongly tide dominated, therefore wave ravinement surfaces are rare and tidal ravinements predominate. Numerous depositional environments can be reported within these early transgressive deposits: a common feature of the Langhian sequence consists of early TST dark shales infilling the base of the valley incised in shoreface sandstones or in underlying shelf shales when the depth of the valley incision increases. These shales include mangrovia facies with Avicenia pollen and locally roots. Good examples of such deposits occur near Istres as well as all along the eastern margin of the Valréas basin and in Chateauredon in the proximal part of the basin, in association with oyster bearing lagoon. Above these paralic shales, RS occurs overlain by late TST open shelf bioclastic tidal dunes or sandy facies.

A second facies association which occurs within early TST comprises lacustrine limestones or lagoonal limestones and marls with foraminifera; this example is documented in the upper Burdigalian sequence in Forcalquier syncline below the RS. In this syncline, a third facies association is observed within the early TST, including thin tidal flat characterized by rippled sandstones. These facies pass laterally to each other over short distances. In other sub-basins of the foreland, they might even be unusually thick, such in Carpentras basin or in Royans Syncline (Northern Subalpine Ranges) where a complete succession grading from Mixed flat-Sand Flat and Tidal channels is observed below the RS and in turn overlain by compound bioclastic tidal dunes. Similar facies association are observed in younger Serravallian sequences along La Lance Mountain in Valréas basin where these facies are developed below the Molasse of Suze la Rousse and overlie langhian offshore marls.

In conclusion, early trangressive deposits developed below the RS appears to be much more frequent than commonly admitted and we have to think about them each time we have to perform sequence stratigraphy analysis more specifically when dealing with uncored subsurface data.

MULTIPLE ALTERATIONS OF THE TRACE METAL INVENTORY IN PERMIAN KUPFERSCHIEFER DEPOSITS BY CHEMICALLY DISTINCT FLUIDS

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The upper Permian Kupferschiefer, a bituminous clay/marlstone, is one of the most renowned strata-bound metal deposits worldwide. It was deposited in an epeiric sea formed by intrusion of marine waters into the Central European Zechstein Basin during a global transgression. Restricted water circulation lead to a rapid development of anoxia with bacterial sulfate reduction providing excellent preservation of organic matter and syndepositional enrichment of trace metals (e.g. Ni, Mo, V, U) via precipitation from seawater. In addition, a redox front migrating downwards into underlying clastics leached metals, which were then re-precipitated in the basal Kupferschiefer or in directly underlying strata. Besides syngenetic trace metal enrichment epigenetic mineralization, controlled by basin architecture, occurred and was mainly bound to areas were the Kupferschiefer is underlain by Rotliegend red beds. Oxidizing fluids circulating through these red beds became enriched in certain trace metals, which were then re-precipitated as sulfides in the reducing Kupferschiefer environment, whereby the organic matter became oxidized.

Here we present a complex, multistage scenario of Kupferschiefer mineralization from the Thuringian Basin, a sub-basin located at the southeastern margin of the Kupferschiefer Sea. Samples derive from core Kal Buttlar reveals a highly heterogeneous trace metal zonation that can be attributed to primary metal accumulation modulated by secondary alteration processes. Our geochemical data allowed distinguishing at least two stages of trace metal enrichment, followed by a phase of trace metal dissolution and re-distribution. Syndepositional enrichment of trace metals (e.g. Ni, Mo, U, V) occurred in dependency of redox conditions and the evolution of H_2S concentration in pore and bottom waters. Epigenetic processes, associated with circulating fluids in underlying red beds, resulted in a significant enrichment of Pb (~0.6 wt.%), Cu (~2 wt.%) and Zn (~3 wt.%).

In Core Kal Buttar we further document a complex stratigraphic zonation of the overall trace metal inventory, with distinct horizons enriched, while others depleted in certain trace metals (As, Cu, Ni, Mo, Pb, Zn). Horizons depleted in trace metals show low sulfur abundances, attesting to the remobilization of sulfides. Analysis of the remaining sulfides via electron probe analysis confirmed that those mainly consist of euhedral chalcocite, sphalerite and galena, while framboidal pyrite is nearly absent. Metal depleted horizons are further highlighted by reduced organic matter (TOC) content and hydrogen richness (Rock Eval –HI values), higher thermal maturity of organic matter (Rock EvalTmax values), as well as elevated $\delta^{15}N$ and $\delta^{13}C_{org}$ isotope signatures, which attest to a significant postdepositional alteration of the sedimentary organic matter.

These distribution patterns of metals and organic matter are explained by a bedding-parallel intrusion of hot metal-depleted fluids that accessed bedding planes along fractures and then followed zones of weakness or higher permeability parallel to bedding. Late intruding fluids may have originated from previously leached red beds, resulting in low metal concentrations of these oxidizing brines. The fluids then caused an intraformational mobilization and re-precipitation of sulfides hosting the majority of the trace metal inventory and a coeval alteration of the sedimentary organic matter.

THE EARLY TOARCIAN ENVIRONMENTAL CRISIS: MECHANISMS AND CONSEQUENCES OF AN ICEHOUSE-GREENHOUSE TRANSITION

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Mechanisms triggering the Early Toarcian global warming (Early Jurassic; ~183 Ma BP) and associated environmental perturbations, comprising ocean acidification, sea level rise, shelf sea anoxia, black shale deposition and diversity loss in marine ecosystems are debated controversially. Environ-mental changes were accompanied by a major perturbation of the global carbon cycle, expressed by a negative carbon isotope excursion (Toa-CIE) with a magnitude of about -3 to -4‰. The Toa-CIE can be interpreted to reflect the injection of ^{12}C-enriched carbon into the Earth's ocean and atmosphere system, whereas carbon sources and mechanisms of carbon release remain disputed. Moreover, a precise timescale of the Early Toarcian environmental crisis and the carbon cycle perturbation is under debate.

Here we present an integrated approach, comprising sedimentology, continuous core scanning techniques, inorganic, organic and isotope geochemistry that have been applied to an exceptionally wellpreserved sediment core from the NE Paris Basin. The new high-resolution data set allows discussing mechanisms of global warming, carbon cycle perturbation and environmental change during the Early Toarcian. Based on the results we propose a new and unifying model that explains the key-features of the Early Toarcian and links them into a coherent Earth system concept.

Key features can be explained by the intensive response of the Earth's sensitive cryosphere (polar ice caps and cryosphere-stored carbon) towards an only moderate global warming. The formation of a persistent cryosphere during the late Pliensbachian cold phase was associated with an increase of the cryospherestored carbon pool and with the formation of persistent polar ice caps. The cryosphere became destabilized by a rise in global temperature, initiated by the emplacement of the Karoo-Ferrar flood basalt volcanism. Melting of polar ice caps can explain the rapid sea level rise and the freshening of the Western Tethyan shelf sea that occurred synchronously with the increase in global temperatures. Moreover, the demise of cryosphere-stored carbon and the release of ^{12}C-enriched carbon into the Earth's ocean-atmosphere system can explain the Toarcian carbon cycle perturbation. Global warming, sea level rise and carbon release occurred synchronously in discrete steps and were paced by changes in the Earth's solar orbit. The stepwise nature of this event can be associated with single hyperthermals, whereby each hyperthermal was connected with an individual methane gun of less than 100 kyr in duration. Release of greenhouse gases from the cryosphere caused a positive feedback and drove the Earth's climate into an extreme greenhouse phase. A stepwise change in environmental conditions over a period of > 0.5 Myr may explain the low extinction rates documented for nektonic ecosystems.

Black shale deposition on the Western Tethyan shelf reflects the local response of a shelf environ-ment towards global warming, sea level rise, acceleration of the hydrological cycle, increased nutrient fluxes and eutrophication. Paleogeographic features of the Western Tethyan shelf, comprising hydrological restriction and connection with the Arctic Ocean via the Viking Corridor that allowed the inflow of Arctic freshwater from melting ice sheets, further contributed to the establishment of water column stratification and prolonged bottom water euxinia.

A HIGH-PRECISION NUMERICAL TIME SCALE FOR THE TOARCIAN STAGE: IMPLICATIONS FOR TIMING OF THE MARINE TOARCIAN OCEANIC ANOXIC EVENT (T-OAE) AND KAROO-FERRAR VOLCANISM

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The Early Jurassic (201.3 to 174.1 Ma) started with the end-Triassic mass extinction associated with global warming, which was followed by the Late Pliensbachian cooling and Early Toarcian warming events and the Toarcian–Aalenian shift to (globally) significantly cooler conditions. This interval is further marked by the Early Toarcian Oceanic Anoxic Event (T–OAE), with possibly the largest exogenic carbon-cycle perturbation of the Mesozoic Era, and related changes in climate and the environment, thought to be linked to emplacement of the Karoo and Ferrar Large Igneous Provinces. Strongly enhanced atmospheric pCO_2 and hydrological cycling at this time likely led to elevated global weathering, enhanced nutrient supply to marine and lacustrine basins, and increased productivity and preservation. The T-OAE is also typically marked by a major negative carbon-isotope excursion (CIE) due to the massive (and rapid) release of isotopically depleted carbon. Increasing evidence, however, suggests that the observed negative CIE is super-imposed on an overall, much longer, positive excursion in $\delta^{13}C$, which began in the latest Pliensbachian and likely reflects elevated global carbon drawdown. Although much research has focused on events during the negative CIE associated with the T-OAE, the Toarcian time-scale and the temporal link between Early Toarcian marine events and emplacement of the continental Karoo and Ferrar igneous province is poorly understood.

Here, we present high-resolution carbon-isotope, elemental-concentration and magnetic-susceptibility data from the Mochras Borehole (Wales, UK), which is ~1300 m thick and uniquely combines stratigraphic expansion and biostratigraphic completeness. We show that the Early Toarcian was marked by a strong 3–4 per mil positive excursion in $\delta^{13}C$ (spanning from the uppermost Pliensbachian *spinatum* ammonite zone to the Toarican *bifrons* zone), which is interrupted by a ~7 per mil stepped negative CIE. We construct a 'floating' astronomical timescale from magnetic susceptibility and elemental Ca concentration for the entire Toarcian Stage and all constituent biozones. We show that the Toarcian stage is of ~7.2 Myr duration, with the full Early Toarcian negative CIE lasting ~1.7 Myr and the overall positive CIE lasting ~4.3 Myr. Observed stepped negative shifts in the negative CIE have previously been attributed to astronomical forcing and we show that they likely occurred at short (combined ~100 kyr) eccentricity periodicities.

Combined with radio-isotopic constraints on Toarcian biozone boundaries we use the 'floating' Toarcian astronomical timescale to establish a numerical time-scale for the complete Toarcian Stage. With this we compare the timing of Early Toarcian events observed from sedimentary archives with the emplacement of Karoo and Ferrar magmatic rocks. This comparison indicates that the onset of the positive carbon-cycle excursion and associated changes in global weathering rates at the Pliensbachian– Toarcian transition, reconstructed from evolving $^{87}Sr/^{86}Sr$ and $^{187}Os/^{186}Os$ ratios, overlaps in time with the onset of the main phase of Karoo-Ferrar volcanism. Consequently, we argue that the observed Early Toarcian negative CIE did not occur as a direct consequence of volcanogenic carbon release, but rather in response to injection of ^{13}C-depleted carbon into the ocean–atmosphere system from other sources, such as seafloor methane clathrates.

SEDIMENT WAVES FROM SHELF-EDGE DELTAS IN THE GULF OF LIONS (NW MEDITERRANEAN SEA)

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Late to Middle Pleistocene asymetric wavy bedforms have been mapped within 2 seismic units at the shelf edge in the Gulf of Lions. They are 3 to 8 m in height and their spacing ranges from 110 to 620 m. Their internal architecture displays depositional lee side and erosional stoss side, with a landward net migration and positive angle of climb. This architecture, as well as the continuity of internal reflections between bedforms, suggest that they are sediment waves, not creeping features. The dense grid of seismic data allowed us to map the extent of the 2 units. They display a lobate shape with a maximum thickness of 13 m (upper unit) and 23 m (lower unit), the conversion from travel time being based on velocity measurements along the borehole and core data. Calypso cores and the PROMESS PRGL2-2 drill site provide chronostratigraphic and litho-stratigraphic constraints. On cores, the wavy bedforms correspond to alternating silty sands and clayey silts, mm to cm thick, with frequent erosional surfaces at the base of sandy intervals. Such deposits are very similar to tempestites described in several lower shoreface/prodeltaic environments. The micro-fauna assemblages from both units indicate depositional environments in the order of 20-50 m below sea-level, likely to correspond to prodeltaic environment. The upper unit formed between Heinrich Event 3 and the last Glacial Maximum (ca. 30-20 kaBP), in a framework of forced regression. The time constraint for the formation of the lower unit is less precise, with a time window between MIS 8.2 and MIS 7.4 (ca. 260-220 ka BP), but very probably corresponds to the onset of the termination III, considering the fact that this unit onlaps on the shoreface sands of MIS 8.2. In this presentation, we will review different scenarios for formation processes, and propose that the sediment waves correspond to anti-dunes developed during periods of intense high-concentrated flows at the mouth of mountainous streams. Similar features have been recently described on some modern (highstand) Mediterranean prodeltas. Their forced regressed or early transgressive counterparts are more likely to be preserved, as demonstrated by several occurrences of such sediment waves in the NW Mediterranean Sea and elsewhere.

ORIGIN, CHARACTERISTICS AND POTENTIAL IMPACTS OF VOLCANIC ASH BEDS FROM THE VACA MUERTA FORMATION, NEUQUÉN BASIN, ARGENTINA

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As many other petroleum source rocks in the world, the Vaca Muerta Fm (Tithononian-Vallanginian, Neuquén basin) contains numerous centimetric thick ash beds. These ash beds, cumulatively representing up to 2% of the entire Formation, are important to study because of their potential role in the hydraulic fracturing propagation in unconventional oil/gas shale production. They may also have played a role as fluid carrier beds during diagenesis and early primary oil migration. An exhaustive study of these ash beds, based on petrophysical, mineralogical and geochemical study, was thus carried out. Two main families of ash beds were recognized. The first family, the calcite cemented ashes, is characterized by argilitized glass shards, pumice fragments and vesicles particles (10-20%) associated with mineral fragments supported in a calcitic matrix (50-75%). These ashes are shown to have had excellent initial reservoir qualities allowing for an early calcification. The second family, the clay-rich ashes, is characterized by an illite/smectite assemblage matrix (20-70%) with mainly albite phenocrystals locally altered into calcite. As a matter of fact, during volcanic eruptions, two main phases of ash ejection are commonly distinguished. A first phase of ash ejection containing microlithes and volcanic glass is dense with a blocky texture. These ashes are transported over relatively short distances and correspond to the clayey ashes (volcanic glass illitization). This family of ashes is currently among the most porous facies of the Vaca Muerta source rock, many levels of ash beds from early mature setting bearing oil. A second phase, with lighter and more vesicularized ashes, is ejected and transported further away. Another process of ash distinction occurs during ash decantation resulting in normal sorting with the cemented ashes often overlying the clay ashes. A trace elements study enabled to confirm the origin of the associated volcanic series, i.e. calco-alkaline with andesites and rhyodacites in an andesian back arc setting.

USING THE MESSINIAN SALT GIANT AS A TEMPLATE FOR EARLIER SALT GIANTS

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Common characteristics for the generation of many salt giants include: 1) substantial pre-existing accommodation space, 2) precursor anoxia, 3) precipitation in thick bodies of stratified hypersaline water with individual beds/laminae continuous for tens to hundreds of kilometers, 4) fluid inclusions symptomatic of brines derived from contemporary ocean water, but not always having evolved along a simple evaporation trend, 5) periods of isolation from an external ocean via a barrier that is sometimes permeable, 6) evaporative drawdown causing regions of the basin floor to dry and others to become coastal sabkha and alkaline lakes, 7) addition of non-marine waters that dissolve and recycle existing evaporites, 8) mass-wasting of former margins inducing avalanches and mass-flows with associated evaporite breccia and turbidites. Salt giants occur in rifts, along continental margins of opening oceans, in back arc basins, and in closing seaways. Barriers over which and through which seawater enters include reefs, island arcs and hotspot chains. Salt giants extract and sequester sufficient solutes from the external ocean to reduce global carbon, calcium and sulfur reservoirs, alter climate, affect ocean circulation, and disturb marine productivity. Salt giants display similar styles of ductile flowage with the expression of extension, translation, compression and diapirism. Rapid accumulation of extremely thick deposits induces lithospheric loading with both local and far-field consequences. Many salt giants terminate in lacustrine and terrestrial environments without completely filling the available accommodation space and are followed by an abrupt return of fully marine conditions.

SEDIMENTARY LIFE CYCLE OF A FAULT CONTROLLED, FINGER LIKE DEPOCENTER

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Komjatice depression is a partial finger like bay of the Danube Basin (Pannonian basin system). The first data on the Neogene fill of the depression comes from the exploration wells, drilled in the 60th and 70th. These wells brought information on lithostratigraphy, petroleum systems and the discovery of the Ivanka-Golianovo reservoir led to further exploration. The presented study aims to reevaluate the depositional history of the sedimentary fill by using facies analysis, petrography and biostratigraphy on recently resampled deep wells. Seven tectonosedimentary cycles were recognized. 1. Sarmatian (Serravallian, ~12.8) pre-tectonic alluvial deposits, with provenance mainly in the Paleozoic rocks. 2. Sarmatian (late Serravallian, ~12.8) early syn-tectonic terrestrial to marine/brackish deposits connected with volcanic activity. 3. Sarmatian (latest Serravallian, ~11.8 Ma): syn-tectonic stage connected with the Ser3-Ser4/Tor-1 highstand. Shelf-slope sedimentation progressively fills the whole depocenter from the E towards SW. 4. Pannonian (Tortonian, ~11 Ma) post tectonic alluvial fan and fan-dela deposits (Nemčinay) 5. Pannonian (Tortonian, ~10 Ma) maximum flooding (Ser4/Tor-1Tor2). Deposition takes place in shelf-slope to basin floor environment. 6. Pannonian (Tortonian, ~9.5 Ma). shelf-slope to basin floor deposition continues and the shelfs are dominated by deltaic deposits and prograde towards the SE. 7. Pannonian (Tortonian, ~8 Ma). The depocenter is fully filled and alluvial environment dominates.

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6-KYR RECORD OF FLOOD FREQUENCY AND INTENSITY IN THE WESTERN MEDITERRANEAN ALPS – INTERPLAY OF SOLAR AND TEMPERATURE FORCING

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The high-resolution sedimentological and geochemical analysis of a sediment sequence from Lake Savine (Western Mediterranean Alps, France) led to the identification of 220 event layers for the last 6,000 years. 200 were triggered by flood events and 20 by underwater mass movements possibly related to earthquakes that occurred in 5 clusters of increase seismicity. Because human activity could influence the flood chronicle, the presence of pastures was reconstructed through ancient DNA, which suggested that the flood chronicle was mainly driven by hydroclimate variability. Weather reanalysis of historical floods allow to identify that mesoscale precipitation events called "East Return" events were the main triggers of floods recorded in Lake Savine. The first part of this palaeoflood record (6 to 4 kyr BP) was characterized by increases in flood frequency and intensity in phase with Northern Alpine palaeoflood records. By contrast, the second part of the record (i.e., since 4 kyr BP) was phased with Southern Alpine palaeoflood records. These results suggest a palaeohydrological transition at approximately 4 kyr BP, as has been previously described for the Mediterranean region. This may have resulted in a change of flood-prone hydro-meteorological processes, i.e., in the balance between occurrence and intensity of local convective climatic phenomena and their influence on Mediterranean mesoscale precipitation events in this part of the Alps. At a centennial timescale, increases in flood frequency and intensity corresponded to periods of solar minima, affecting climate through atmospheric changes in the Euro-Atlantic sector.

SEDIMENTARY HISTORY OF THE BARENTS SEA FOR THE LAST 40 KA CAL BP

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The continental shelf of the Barents Sea is characterized by tracks of erosion showing the presence of the ice sheet of Barents-Kara Sea. These incisions correspond to paleo-ice stream that drained the ice sheet, playing a crucial role in global circulation, injecting fresh water into the Atlantic Ocean.

Seven sedimentary cores (KC11, KC12, KC13, KC14, KC15, KC05, KC04) collected during the mission SHOM MOCOSED 2014, off and on the Bear Island ice stream, on the path of the Norwegian Current, were analyzed to characterize the shallow and deep sedimentation of the area. A stratigraphic study was realized by comparing several parameters: the magnetic susceptibility and IRD concentration, with a reference core: the MD95-2012, near the study area. Then sedimentary analyzes (rX imaging, XRF ratio microgranulometry) and micropaleontological were compared to determine sedimentary facies. CHIRP seismic profiles were also interpreted.

All these analyzes have revealed several facies have defined three sediment transport processes of the continental shelf to the deep ocean: the ice rafting, turbidity current and debris flows. Submarine slides were recorded in seismic profiles and slide scars and deposits were identified on the swath bathymetric data.

While debris flows impact the entire length of the continental slope, the turbidity current's activity decreases from the coast of Norway to the Bear Island trough. Several hypotheses were proposed to the processes to the origins of flows: cascading by Brine rejection and fluvio-glacial activity. Finally, the submarine slide on the Bear Island Trough Mouth Fan seems have been multiphased, with its last phase of destabilization dated at 16.8 ka BP, synchronous with the Heinrich event 1.

CLASSIFICATION OF CHALK MICROTEXTURES: SEDIMENTARY VERSUS DIAGENETIC ORIGIN

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Microtexture describes the type and arrangement of particles in matrix samples at Scanning Electron Microscopy scale. A microtexture classification exists for micritic limestone, but not for chalk. This study therefore proposes a classification of chalk microtextures and discusses the origin of microtexture variability. Chalk was sampled at thirteen spatio-temporal locations along the coastline of northern France (Cenomanian – Santonian).

Four categories of criteria are defined to describe and characterise chalk microtexture: mineralogical content, biogenic fraction (< 10 µm), micritic fraction (< 10 µm), and cement fraction (> 10 µm). From these criteria, two major groups are defined: Pure Chalk Microtexture, with classes from 1 to 7; and Impure Chalk Microtexture, divided into two subgroups: Argillaceous Microtexture, with four classes, dispersed clays, unoriented clays, oriented clays, and draped clays; and Siliceous Microtexture, with spherulitic opal-CT, and draped opal-CT.

Microtexture variability is related both to initial sedimentation and to diagenesis. Sedimentological conditions (e.g. climate and distance from shore) affect chalk composition (carbonate content and type of insoluble particles), thus influencing microtexture. Changes in Pure Chalk Microtexture from microtextures 1 to 7 are the result of increasing diagenetic intensity.

For the Pure Chalk Microtexture Group, diagenetic transformation induces a decrease in pore size, with better grain contact, but not a decrease in pore-throat size. These transformations explain the decrease in porosity, the improved propagation of acoustic P-wave velocity, and the absence of any specific variation in permeability with increasing diagenetic intensity.

For the Impure Chalk Microtexture Group, the percentage of carbonate content is not linked to porosity, but the type of non-carbonate particles can affect porosity (e.g. fibrous clays). Non-carbonate particles reduce pore-throat size (Mercury Injection Capillary Pressure data), thus explaining lower permeability at a given porosity than for Pure Chalk Microtexture.

This classification can be used to characterise onshore and offshore chalk microtextures (e.g. reservoir and non-reservoir North Sea Chalk). Reservoir quality depends on the petrophysical and mechanical properties of reservoir rocks, which can be better understood by exploring their sedimentary and diagenetic history, revealed by the study of chalk microtexture variability.

A SEDIMENTARY AND GEOCHEMICAL RECORD OF MILLENNIAL-SCALE TROPICAL CLIMATE CHANGE DURING THE TOARCIAN OCEANIC ANOXIC EVENT

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The Toarcian Oceanic Anoxic Event (T-OAE) represents a period of significant global warming (183 Ma), forced by large-scale carbon release to the atmosphere, and marked by a widespread negative carbon isotope excursion in the rock record. This event caused mass extinction, profound changes in marine ecosystems, acceleration of the hydrological cycle and an increase in the extent of oceanic anoxia. Studies of this event are concentrated in Western Europe (palaeo-Tethyan-Boreal seaway) and at mid latitudes, leading to a geographical bias in our knowledge of the event. This limits our understanding of the variability of both the extreme climate change and the response of the Earth system.

We have investigated a previously unstudied succession from the Middle Atlas Basin, Morocco (palaeolatitude ~20°N), which provides an expanded record of the T-OAE. This section is over 2 times as thick as the thickest recorded European T-OAE section, and is marked by an 8‰ negative organic carbon isotope excursion.

High-resolution carbon isotopic and elemental concentration data, from this new section in Morocco, have been integrated with detailed sedimentary logging and biostratigraphy. Our record provides the highest-resolution insight into climate change during the T-OAE in the tropical Northern Gondwanan region.

Our study reveals regular cyclic carbon isotopic and sedimentary facies variation, on Milankovitch timescales, across the event. This finding demonstrates an intrinsic link between the carbon cycle, local sedimentology, and climate. Moreover, it also enables refinement of the T-OAE timescale, which is muc debated. Combining our new temporal framework with our high-resolution palaeoenvironmental records from Morocco, and established European records, provides new insights into millennial-scale Earth system dynamics during the T-OAE, across a latitudinal gradient.

PROGRADATION OF THE EXORHEIC SYSTEM OF OUED OUADRANE, SOUTHEAST TUNISIA: LOCAL VERSUS GLOBAL FORCING

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A 245 cm core carried out in the mouth of Oued Ouadrane shows the upward succession of three facies. (1) The first facies is marine influenced; it is black probably due to an increasing confinement and rich in marine fauna. It is marked by low values of the magnetic susceptibility. The sedimentary, paleontological and magnetic indicators are in favor of lagoon, bay or estuary depositional environment. (2) The second facies is marked by red and azoic silt to clay sediment. High values of the magnetic susceptibility are due to an increasing continental feeding. Nonetheless, the fine grain size distribution files a case for the setting of a prodelta depositional environment. (3) The third facies shows more pronounced continentalization with the appearance of a continental fauna. The coarse grain size distribution is in favor of delta depositional environment. The succession of these three facies shows a seaward progradation of the Oued Ouadrane system. The forcing of this progradation may by local due to a local subsidence as it may be generated by a global major forced and/or natural regression.

CLIMATE VARIABILITY IN THE SOUTHWESTERN MEDITERRANEAN (EASTERN TUNISIA) DURING MIDDLE TO LATE HOLOCENE: RECONSTRUCTION OF MILLENNIAL TO CENTENNIAL CLIMATE CYCLES

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We carried out a high-resolution multiproxy sedimentological and geochemical investigation of a Late Holocene sequence of sebkha sedimentary filling in Southwestern Mediterranean. Magnetic susceptibility measurements were performed to provide a proxy for the relative extent of humid and arid climate periods. An age model for the sedimentary sequences was built based on the radiocarbon AMS ^{14}C dating method and the cyclostratigraphic approach. The warm periods are associated with the relatively low values of magnetic susceptibility (MS). These events correspond to colder intervals which registered both high solar modulation and sun spot number. Informative paleoclimate proxies of Tunisian, central Asia and North Atlantic, were compared to our main results. It has been shown that the periods of humid climate occurred during cold phases, supposing climatically-controlled processes forcing the occurrence and recurrence of these periods. Spectral analysis of our results demonstrates periodic changes of ~2500, ~1500, ~1200, ~1000, ~500, ~230, ~130, ~74 years of relatively warm and cold intervals during the Holocene of Mediterranean. It seems that the ~1500-year cycle related with the NAO occurs only in the Late Holocene. Three time periods ~9400–10500, ~4100–5500 and ~900–1900 years BPcorrespond to low sun spot number and the most developed humid periods in the sebkha Ennoual.

EARLY DIAGENETIC EVENTS IN LATE KIMMERIDGIAN CARBONATE RAMPS (IBERIAN BASIN, NE SPAIN): IMPLICATIONS FOR OUTCROP CHARACTERIZATION AND DECIPHERING AND PREDICTION OF CARBONATE RESERVOIR HETEROGENEITY

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Simulation of hydrocarbon production behavior and estimation of the recovery methods underpin economic forecasting in field development. For this purpose, a proper and detailed geological model including the architecture of the main geological bodies within the reservoir is initially required. Reservoir modelling involves not only the vertical and lateral characterization of the main drains (highly connected permeable layers), but also that of barriers and baffles (continuous low permeability layers) that may compartmentalize the field. High-resolution and integrated analysis and modelling appear to be key tools to predict the spatial distribution of reservoir quality in many carbonate fields, combining sequence stratigraphy and diagenetic analyses.

Geological models from analog outcrops enhance or challenge the understanding of multi-scale sedimentological and diagenetic heterogeneities in the subsurface reservoir models, in particular by providing provide scenarios for stratal framework, sedimentary and diagenetic facies models. For this purpose, two upper Kimmeridgian outcrops (NE Spain) have been studied from a conventional diagenetic perspective (petrographic microscopy analysis and cathodoluminescence) to assess the impact of diagenetic modification. More than 60 thin sections have been used to define a paragenetic sequence and a set of early diagenetic events in carbonate ramp systems. Additional mineralogical mapping (Qemscan®) serves as a calibration tool for quantitative analytic studies of every mineral phases and inferred porosity-types. The resulting events were mapped using 3D outcrop characterization (using drone acquisition photogrammetry and hyperspectral imaging) defining geobodies at reservoir scale. Ultimately, high-sequence stratigraphy allows linking these events to certain environmental domains responding most-likely to sea level fluctuations.

Petrographic and geochemistry studies of the upper Kimmeridgian succession are focused on prin- cipal diagenetic processes prior to compaction during burial affecting the grainstone and reefal sedimentary bodies. Thus, they offer valuable data that would be potentially relevant to unravel reservoir parameters from microscopic to inter-well scale. In addition, the outcrop analogs provide spatial trends and patterns for certain (relevant) diagenetic processes that can be utilized in similar subsurface settings as soft trends and/or “bodies”. Examples here are cementation processes plugging primary interparticle porosity of these subtidal carbonate deposits; the creation of tight concretion nodule fabrics when these platforms are subaerially exposed; and pore-enhancing processes such as micritization of carbonate grains and reflux dolomitization of mid ramp domain. The trends and patterns (e.g., bodies) of diagenetic trends as well as the underlying facies heterogeneity can be compared with petrophysical properties from plugs and logs from the subsurface and, next, used as input parameters (soft constraint) in iterative static reservoir modeling of carbonate ramps.

NEOGENE BASIN INFILLING FROM COSMOGENIC NUCLIDES (^{10}BE AND 21NE) IN ATACAMA, CHILE

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In the hyperarid Atacama Desert, northern Chile, Neogene sediments host enriched copper rich layers (exotic supergene mineralization). Current mines are excavated into relatively thin. First, ^{21}Ne gives lower boundaries for upstream erosion rates or local sedimentation rate. These bounds are between 2 and 10m/Myrs, which is quite important for the area. The ratio between the two cosmogenic nuclides indicate a maximum burial age of 12 Ma (minimal erosion rate of 15m/Ma) and is surprisingly similar from bottom to top, indicating a probable rapid infilling. We finally processed a Monte-Carlo inversion. This inversion helps taking into account the post-deposition muonic production of cosmogenic nuclides. Inversion results is dependent on the muonic production scheme. Interestingly, the similarity in concentrations from bottom to top pleads for quite low production at depth. Our data finally indicate a quick infilling between 12.5 and 10 Ma BP accounting for ~100m of deposition (minimum sedimentation rate of 40 m/Ma).

ARSENIC IN MICROBIAL MATS OF LA BRAVA: DISTRIBUTION, REDOX STATE AND (BIO) GEOCHEMICAL IMPLICATIONS

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Arsenic is a notorious toxic element, and as such may have exerted a strong selective pressure on the evolution, and the distribution, of life on Earth. Documenting the abundance, distribution, speciation and inter-element correlation of arsenic in living microbial mats can help to advance our understanding of the biogeochemical cycle of arsenic in ancient microbial mats, recorded in sediments. In this work, we studied a microbial mat from laguna La Brava, a hypersaline lake in the Atacama Desert (Chile). This environment represents a potential living analogue of the ancient Earth (e.g. high UV, lack of O_2 in sediments). Laguna La Brava receives a groundwater input containing leached volcanic material, transporting a high concentration of arsenic and sulfide to microbial mats. Hence, the growth of these mats is possibly driven by anoxygenic photosynthesis using reduced sulfur and arsenic compounds. Oxidative processes in these mats could include fermentation, methanogenesis, sulfate, and likely, arsenate reduction. The diversity in these mats is dominated by archaea and sequences for Haloarchea, which have preserved arsenic metabolims for a very long time, linking this to ancestral matabolisms that prevailed on ancient Earth. Combining X-ray micro-fluorescence (µXRF) with X-ray Absorption Near Edge Structure (XANES) imaging together with traditional geochemical observations provided constrains on identifying geochemical proxies of the As-based metabolisms occurring within these mats.

SEDIMENTOLOGICAL AND PETROPHYSICAL ANALYSIS OF THE LOWER LEKHWAIR OF THE UAE, RESERVOIR QUALITY AND INFLUENCE OF MATRIX MICRO-CEMENTATION

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The Early Cretaceous carbonate deposits of the Lower Lekhwair have been studied in detail in nine cored wells from the UAE. Sedimentological analysis of cores enabled discrimination of seven different facies but showed that only three constitute most of the depositional sequence. Two of these three facies are algal-rich (ASPFR & ASFB facies) with the third defined as algal-poor (SPP facies). A depositional environment model has been created and exhibits a broad and shallow inner shelf where numerous small and patchy individual Lithocodium-Bacinella build-ups developed on the sea floor that gathered into larger-scale build-up clusters. Algal-rich facies constitute the build-up deposits and algal-poor facies the inter build-up deposits. The vertical and lateral extension of the algal facies in this model is very limited (metre-scale buildup structures).

A detailed diagenetic study based on petrography and fluid inclusion analyses was conducted. It reveals a complex diagenetic history with at least 18 different diagenetic phases. Established paragenesis indicates that sediments were modified from near surface (early diagenesis) to deep burial (late diagenesis). Major grain dissolution occurred quite early in the sediment history and is probably linked to the subaerial exposure period interpreted at the top of the reservoir (regional sequence boundary). Cementation phases include the precipitation of non-ferroan and ferroan calcite, followed by the precipitation of ferroan saddle dolomite. Fluid inclusion analyses indicate a shallow burial origin for the calcite cement and a deep burial origin for the dolomite cement.

Porosity logs from the studied wells display important heterogeneities, with multiple major decreases in porosity values that can sometimes be correlated between wells and interpreted as potential sequence boundaries. From the core descriptions these decreases could have been related to the presence of major stylolites. The greater the distance from these major stylolites, the better the reservoir quality. In cores no obvious change in porosity around the stylolites could be ascertained from visual estimation. However, the few MICP curves available display a net displacement of the microporosity volume toward higher pressures for the samples at greater proximity to the major stylolites. This observation clearly indicates the occurrence of a micro-cementation process within the sediment matrices related to the stylolites development. These important local decreases in porosity engender a certain compartmentalisation of the reservoir.

Combination of available CCA measurements with core and semi-quantitative petrography analyses enabled the major controlling factors on the reservoir quality to be established: the depositional facies (algalrich facies represent generally better reservoir than algal-poor), the sediment texture (grain-stones represent generally better reservoir than packstones, which in turn represent better reservoir than wackestones) and finally the presence or absence of matrix micro-cementation due to the stylolites developments (patchy macro-cementation of calcite and dolomite appears to be only a secondary controlling factor).

PANGEA BREAK-UP AND THE SIGNIFICANCE OF RECURRENCE CYCLES IN PERMIAN ASH LAYERS FROM THE IRATI FORMATION, BRAZIL

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The intracratonic Paraná Basin is located on the eastern side of the South American Platform and is made of sedimentary and volcanic rocks that are grouped into six second order sequences: Rio Ivaí, Paraná, Gondwana I, Gondwana II, Gondwana III and Bauru. The Gondwana I sequence includes the Irati Formation (Passa Dois Group), in which are found volcanic ashes intercalated with organic-rich mudstones and dolostones. These rocks are well exposed at the Petrox-Six Quarry São Matheus do Sul (PR). The zircon U-Pb data from these ash layers indicate ages ranging between 287 and 267 Ma, with a main peak at 278 Ma. Lu-Hf data of these zircons indicate a crustal signature εHf ranging between -7 and -3 and Mesoproterozoic 1.2 (Ga) and Neoproterozoic 0.8 (Ga) Hf (TDM) model ages. The Nd isotope data reinforce the zircon data, indicating a main crustal component in the source area of these rocks εNd = -11.6 to -3.3. The data indicate that the volcanic ash beds interlayered in the sedimentary rocks of the Irati Formation are related to the Choiyoi volcanic province that is approximately 2.000 km to the west.

STRUCTURE AND EVOLUTION OF THE SOUTHERN MARGIN OF THE SO-CALLED MAULEON "HYPER-THINNED" RIFT BASIN (WESTERN PYRENEES, FRANCE)

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The Albian Mauleon rift system is located in the western part of Pyrenees (France). This rift basin is interpreted to be related to a hyper-thinned continental crust and an exhumed sub-continental mantle dome. The objective of this study is to understand the sedimentary evolution of this type of rift. This integrated study combines: field data, detailed geological mapping, seismic interpretation and 3D modeling. The field study focuses on the Iberic proximal margin of the Mauleon rift basin.

Mapping and field data analysis permits to unravel the geological history of the southern margin of the Mauleon rift basin. The rifting stage is preceded by a regional uplift related to a lithospheric bulging, during the end of Jurassic to Neocomian. This uplift is followed by the development of a transgressive carbonate platform during the Barremian to Aptian, due to a thermal subsidence. At this stage the depositional profile remained flat, with no differentiation between platform and basin. The tilting of the sedimentary profile towards the north starts between the Latest Aptian and the Earliest Albian. This period is characterized by the back-stepping of the urgonian carbonate platform towards the south and its intercalation into distal marls towards the north. During Albian time, the Mauleon basin is affected by differential vertical movements: [1] uplift of the southern part of the basin and [2] tectonic subsidence towards the north. These movements are responsible of the onset of the Mendibelza conglomeratic gravity flow deposits fed by non-preserved fan-delta systems, reworking the Hercynian meta-sedimentary units. The denudation of the Hercynian "basement" prior to the development of the Mendibelza system is interpreted to be related to: (1) the erosion of the Jurassic cover towards the South during the Early Cretaceous and (2) the mass sliding of the Mesozoic cover towards the future Mauleon basin during the Early Albian. At this stage, the southern margin of the Mauleon rift system is characterized by the absence of titled blocks. The accommodation results from a regional tilting of the Iberic substratum towards the North. Major N120° and N30° synsedimentary normal faults are synchronous to this regional tilting until they are fossilized by the last sequence of the Mendibelza Formation. They are no listric faults as shown by: (1) the absence of progressive unconformities in the Albian deposits and (2) the lack of tilting hanging wall.

Seismic interpretation and wells calibration along a N-S transect of the Mauleon basin, allow us to image the transition with the northern conjugate margin. The synrift record is very different on each side of the Mauleon basin. The southern margin is composed of a proximal turbiditic s.l. system whereas the northern margin is characterized by carbonate platform system. Sedimentary observations and seismic interpretations highlight that the Mauleon rift basin is strongly asymmetric. We interpret this by the coupled action of a southward detachment system and the flowing of the lower crust under the Iberic plate.

CLIMATIC AND ENVIRONMENTAL CHANGE IN THE AFTERMATH OF THE END TRIASSIC MASS EXTINCTION EVENTEVIDENCE FROM THE DORSET SECTION (GB)

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The end Triassic mass-extinction event (eTME ~200.4 Ma ago) has been recognized as one of the five major Phanerozoic extinction events with 40–73 % loss in biodiversity. It caused important floral and faunal turnover on land, major extinction in the marine realm and important geochemical perturbations. The carbon isotope records show a double negative shift (initial and main CIE) during this time. The initial CIE coincides with the eTME whereas the main CIE was recorded afterwards, within the Hettangian, demonstrating that Earth's biosphere did not fully recover for several million years. Indeed, widespread shallow marine anoxia, palynological variations, and climatic change were identified in the aftermath of the eTME. Furthermore, subsequent carbon isotope excursions have been recorded in the Sinemurian interval (*obtusum* zone, early-late Sinemurian; Sinemurian-Pliensbachian boundary). However, the mecanisms and environmental impact associated with these perturbations are still not completely understood. In order to better describe and explain the eTME recovery and the Sinemurian events, we have performed a high resolution (440 samples) multi-proxy geochemical study of the Dorset section spanning from the Hettangian (*Planorbis* zone) to the Pliensbachian (*Margaritatus* zone). The stable carbon isotopes recorded in organic matter and carbonate allows to trace the major carbon cycle perturbations in great detail (Hettangian main-CIE; *obtusum* zone–early late Sinemurian; Sinemurian-Pliensbachian boundary). The associated climatic variations, paleooceanographic change, water oxygenation conditions and productivity will be discussed in this presentation using carbon and oxygen isotopes, bulk-rock and clay mineralogy, the alteration index (CIA), organic matter content (TOC), hydrogen index (HI), phosphorus content and the composition of major and trace elements.

HOT SPRING CARBONATES ASSOCIATED TO A HYPERSALINE LACUSTRINE SYSTEM IN AN ACTIVE RIFT SETTIN (LAKE AFDERA, DANAKIL DEPRESSION, ETHIOPIA)

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Lake Afdera is located in the southern part of the Danakil depression. The latter is a rift valley constituting the northern part of the Afar triangle where three rift systemsthe Red Sea, the Gulf of Aden and the main Ethiopian riftinteract. The lake is caught between bifurcating NNW-SSE oriented segments of the Red Sea rift (Erta'ale, Tatali, and Alayta). These active rift segments are characterized by volcanic complexes and associated hot spring systems. Carbonate buildups found around lake Afdera are the result of numerous active and ancient hot springs set along recent volcanoes, through the Holocene and recent Pleistocene.

The present study follows a "source to rock" approach, focusing on two aspects: (1) the spring water chemistry; and (2) the petrographic and sedimentological characteristics of the precipitates.

Stable isotope analyses reveal a direct connection between the hot springs and the meteoric input from the highly elevated Ethiopian plateau on the western ridge of the depression. However, the subsurface pathway of the water, the role of climate fluctuations and the impact of volcanic activity on the spring water chemistry remain unclear. For this reason, major ion and trace element concentrations have been measured using ICPOES.

The second aspect of this study focuses on the mapping and spatial distribution of the hot spring deposits, as well as its texture and fabric. The hot springs are distributed along lacustrine paleoshorelines, and can be linked to paleo-lake level fluctuations. The porous and permeable carbonate spring deposits are composed of laminated biofilms and crusts, small to large shrubs, sparitic, micritic, peloidal and clotted microfabrics, with encrusted plant remains, ostracods and diatoms. The wide variety of facies associated to different cement generations and calcite replacement reflects the dynamics of the spring system and early diagenetic alteration of the spring deposits.

These results together with additional CT-scanning techniques for high-resolution 3D visualization and SEM analysis will give more insights into the understanding of (1) the environmental conditions for hot spring development in extreme settings and (2) the controlling biotic/abiotic parameters of carbonate precipitation in such hot spring settings.

DISTRIBUTION AND STRATIGRAPHY OF INTRA-CRATER DEPOSITS IN WESTERN ARABIA TERRA, MARS

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Arabia Terra is a regional dichotomy boundary between the high and lowlands of northern Mars known for its densely cratered terrain and extensive distribution of water-altered deposits. By analyzing the intra-crater deposits' stratigraphy and mineralogy, as well as surveying their geographical distribution, the depositional history of Arabia Terra is constrained. 485 craters were observed within a 1,307 by 1,748 km area of western Arabia Terra, bounded by the Oxia Palus quadrangle (MC-11), with the aim to identify and characterize potential water-altered deposits. Several distinct varieties of deposits were found and distinguished by their mineralogy, albedo, thermal-inertia, layering, and erosional landforms. In general, deposits appear either as a thin veneer or a bulky mass that is commonly layered. Veneer deposits were observed in 22 craters and bulk deposits were observed in 55 craters. Geographic relationships between the distribution of intra-crater deposits and areas of extensive plateau deposits, particularly around Mawrth Vallis and Meridiani Planum, suggests multiple upwelling sources of varying depth and intensity at different intervals. Veneer deposits could imply lower intensities and durations of upwellings, or possibly an aeolian redistribution of plateau deposits into craters. A scenario involving a complicated multi-depositional environment of upwelling groundwater, the drainage of plateau surface water, and aeolian processes is proposed for the depositional history of Arabia Terra. Plans for further study include detailed mineralogical, geometrical and stratigraphic mapping to reveal potential indication of water-table level, as well as determining other possible depositional methods.

WIND-DRIVEN HYDRODYNAMICS AND SEDIMENT TRANSFERS IN A LARGE RIFT LAKE (LAKE TURKANA, KENYA)

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Most of the existing depositional models for lakes, and notably those for lakes in rift basins, represent fluvial derived processes at lake margins and farther, and on low-energy settling in distal parts. However, there is a decent number of, modern and ancient, of lakes around the world where sedimentation is influenced or even dominated by wind-induced water circulations. In wind-driven waterbodies (lakes, coastal lagoons, and shallow seas) wind is the primary control on sedimentation. They are defined by the development of typical wave related morphosedimentary features (i.e. beach ridges, spits, cuspate deltas) along their shores and sediment drifts, sedimentary shelf or erosional surfaces on the lake bottom in deeper zones.

Lake Turkana (length: 250 km; width: 30 km; max depth: 115 m; mean depth: 35 m), the largest lake of the eastern branch of the East African Rift System, is such a wind-driven lake. Although some portions of its margins are made of rocky coast, prominent clastic littoral landforms outline its shoreline.

Here we plan to investigate the hydrodynamics of this large but relatively shallow lake from a remote sensing based inventory of the littoral clastic landforms developed along its shorelines, and from numerical simulations (WW3 and SYMPHONIE models) of water circulations forced by different scenarios of wind directions and sediment supply delivered by the Omo River (~90% of the inflow to the lake).

As already performed for previous case studies, winddriven hydrodynamics in Lake Turkana will be inferred from the comparison of the simulated surface and bottom currents with the observed coastal landforms considered as strong markers of alongshore drift. Interpretative circulation patterns with the major currents (barotropic, surface and bottom), zones of up-and downwelling, and sediment sources or sink zones will be presented on synthetic maps. The importance of wind-driven hydrodynamics in a rift lake, and its role on the redistribution of clastics at basin-scale will be assessed. This work corresponds to a preliminary step before further investigations of the hydrodynamics in Lake Turkana at highstand and lowstand, as well as in other rift lakes, of comparable shape (i.e. elongate) but of much greater depth such as Lakes Malawi and Tanganyika.

A CRITICAL REVIEW OF ARCHITECTURAL STYLES IN FORESHORE-TO-UPPER-SHOREFACE SAND BODIES: WHAT DOES PRESERVATION TELL US ABOUT MORPHOLOGY AND CONTROLLING FACTORS?

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Despite the knowledge on morphodynamics of regressive, wave-dominated barrier systems, processes responsible for sand accretion and seaward migration operating in the upper-shoreface and foreshore regions are far from been understood. Additionally, as the morphological configuration of this region can vary from non-barred coasts, to more complex bar-and-trough systems in short time spans (10^1-103), it is reasonable to assume that architectural styles of foreshore-to-upper-shoreface deposits would represent the time-averaged, preserved conditions during accretion. In this contribution we analyze architectural styles of sand bodies developed in recent and ancient regressive barrier systems in order to discuss what information is ultimately preserved and their key controlling factors.

The architectural styles of examples from Cainozoic and Cretaceous times were selected. Cainozoic examples include sedimentology, GPR-based architectural analysis, and reconstructions on gradients and morphology. Outcrop examples where facies and architectural styles allowed to reconstruct gradients and infer morphological configurations, were selected.

Foreshore-to-upper-shoreface architectural styles characterized by closely spaced, foreset beds are dominantly developed when foreshore gradients are > 3° (typically 5-11°), or when they are 2-3° , but with a significant break in slope compared to the upper-shoreface gradient (< 0.5°). Both architectural styles are developed in a wide range of sand grain sizes (very fine to coarse sand), but they differ in stratal geometries and facies distribution. In the first case, foreset beds have a tangential geometry, with faint discrimination between foreshore and upper-shoreface sediments (either in facies or slope). Parallel planar lamination and small-scale trough cross-stratification are common, the latter becoming dominant at the bottomsets. In the second case, inclined foreshore strata (1-3° seaward dipping) downlap onto subhorizontal upper-shoreface deposits together with a distinct change in facies, from parallel planar lamination in the foreshore deposits to large-scale trough cross-stratification in the upper-shoreface strata. These two facies associations can be also present in a third architectural style, but in this case without evident foreshore-related inclined foreset beds. This is by far the most common architectural style described in outcrop, and reconstructing gradients indicate relatively gentle foreshores (1-3°) combined with regular upper-shoreface slopes (0.8-1.9°).

The analyzed dataset suggests that the generation and preservation of any single architectural style seems unrelated to the barrier system (e.g., strandplains, barrier islands) or regressive shoreline trajectory (ascending, horizontal, descending), neither linked to a specific grain-size range. In contrast, each architectural style appears to be associated with the relationship between foreshore and upper-shoreface gradients, and the dominant morphology at the time of accretion. Packages of tangential foreset beds seem to record non-barred conditions and steep profiles, with successive beachfaces accreting seaward on short times. The other two architectural styles attest the preservation of barred conditions and gentler profiles, with dune-related deposits, probably developed in trough settings, gradually overlaid by foreshore sediments. Noteworthy, bar-related deposits (swash or longshore bars) and landward dipping surfaces were hardly ever identified in these examples. Therefore, these macroforms and their short-term migrating processes supplying sand to the beachfaces, though well-documented in modern settings, could be geological features with rather low preservation potential in many regressive barrier systems.

LAKE-MARGIN ICHNOLOGY AS EVIDENCE OF SUBAERIAL EXPOSURE, LAKE-LEVEL FLUCTUATIONS, AND STRATIGRAPHIC PACKAGING IN PLIOCENE TO RECENT KENYAN RIFT LAKES

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Lake-margin sedimentary environments are heterogeneous, particularly in rift lake basins such as those in the Kenya Rift Valley. To interpret the stratigraphic packaging of rift lake successions, we can use trace fossils to help recognize exposure surfaces developed across this heterogeneous setting. This study includes examples from modern to Pleistocene saline lakes (i.e., Bogoria, Magadi, Nasikie Engida), and subsurface examples from Plio-Pleistocene core part of the Hominin Sites and Paleolakes Drilling Project (HSPDP). Modern environments include: (1) a fan delta plain with channels, marshes, and mudflats; (2) coarse-grained wave-reworked shorelines; (3) an axial delta plain to proximal delta front; and (4) low-energy lake-margins with warm-and hot-spring outflow. Environmental conditions (e.g., salinity), observed sedimentary processes, sedimentary structures, biogenic structures, and observed trace producers were studied within the zone of frequent lake-level rise-and-fall. 3-D burrow networks, vertical burrows, and pelletbackfilled branching burrows, produced by air-breathing insects, are common in most of the lake-margin deposits. Terrestrial bioturbation and pedogenesis cross-cut the lake-margin sediments during longer-term exposure, and help to distinguish between short-term lake-level fluctuations and those controlled by longer term allogenic forces (i.e., climate, tectonics).

To interpret the stratigraphic packaging in the HSPDP cores, high-resolution sedimentology and ichnology were used to recognize important exposure horizons. From the cores studied, repeated pack-ages ~4 to ~8 m thick represent lake flooding to exposure cycles, which appear to be controlled by orbital cyclicity. Typically, the deeper water facies grade into marginal facies, which are then pedogenically modified and bioturbated by terrestrial organisms during a drop in base level/water table. In order to delineate the stratigraphic surfaces that separate the packages, it is essential to recognize the most landward facies within the package. In subsurface core however, terrestrial/alluvial and lake-margin settings can be difficult to differentiate. Stratigraphic surfaces are especially cryptic when basinward facies comprise rooted and bioturbated lake-margin sediments, and when pedogenesis on the landward facies is weak.

Based on the modern examples and cores studied, the following are common in the lake-margin settings: (1) earwig (Dermaptera) branching networks of large-sized burrows (< ~1.2 cm); (2) tiger beetle (Coleoptera: Cicindelidae) passively filled vertical burrows (~3-6 mm); and (3) pellet-backfilled burrows (~5-8 mm) produced by beetles (e.g., Staphylinidae, Heteroceridae). These traces are unwalled, filled with material similar to the host, and can have indistinct burrow boundaries. Terrestrial traces are dominated by meniscate-backfilled burrows, breccia-filled tunnels, and backfilled tunnels with spreiten, attributed mainly to termites, and are filled with material moved downward from longterm exposure surfaces (e.g., paleosols).

The differentiation between lake-margin and terrestrial bioturbation is important for interpreting stratigraphic packaging in rift lake successions. Nevertheless, detailed sedimentological analysis must accompany ichnology to interpret conditions and processes. Similarly, roots and pedogenesis cannot be used in isolation to recognize bounding discontinuities for climate-controlled cycles in lacustrine strata.

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ORIGIN AND EVOLUTION OF MODERN OXBOW LAKES ALONG THE ODRA RIVER, CZECH REPUBLIC

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This contribution concerns sediments of a recent oxbow lakes located within the Poodří Protected Landscape Area in the north-east part of the Czech Republic (the Odra River catchment area). The aim of this study is to characterise the initial stages of sedimentary infill. New formed oxbow lakes will be compared to the older oxbow lakes located in the same area.

Two oxbow lakes, located near villages Polanka nad Odrou and Stará Bělá, were created after the floods in 2010 by a rupture of the meander neck. The second one was subsequently filled with sediments which led to quick terrestrialization. Another two oxbow lakes for complementary study, named as Stará Odra and Kukla, were created artificially due to shortening of the Odra River course in the 1960s.

Stratigraphy of bottom sediments was studied from sedimentary cores. Samples were measured for magnetic susceptibility, grain size analysis, visible light reflectance spectroscopy and total organic carbon (TOC) concentrations. Selected samples were analysed using energy dispersive X-ray fluorescence.

Sediment thickness varied from 26 cm to 200 cm. Homogenous or weak laminated silts and clayey silts prevail, especially in Stará Odra, Kukla and distal parts of Polanka lake. Some layers, composed of sandy silts, are evidence of floods. In contrast, fine to coarse sands prevail in Stará Bělá abandoned meander suggesting quick infilling during the flood event in 2010. Coarse sands were found in proximal parts of Polanka lake where they form a plug bar.

Magnetic susceptibility and colorimetric parameters show certain variability, which can indicate seasonal variations in sedimentary conditions, especially spring flood pulses and higher organic productivity in the summer. TOC content is low in Polanka lake. The possible explanation is the rapid degradation of organic matter, because this oxbow lake is still hydraulically connected with the active channel. Conversely, TOC contents were higher in Stará Odra and Kukla lakes, indicating together with elevated sulphur eutrophic conditions.

Sediment accumulation rate is very high in the naturally formed Polanka lake. The lake area has decreased about 57 % since year 2010. Since the same time, abandoned meander Stará Bělá was filled with the sediments fully. In contrast, the older lakes show more stable shape due to their distance from the active channel. The low sedimentation rate was influenced by river regulation. It is evident that sedimentation rate and speed of terrestrialization is faster in the natural river course.

There are significant differences in geochemistry and petrophysical properties of sedimentary fill of lakes which could be caused by a different source of clastic material. Stará Bělá and Polanka lakes are located behind the confluence with the Ondřejnice River (left hand tributary of the Odra River) which has a catchment area in the Mesozoic-to-Kenozoic sediments of the Western Carpathians thrust-fold zone. Whereas other sites, situated upstream, are affected by tributaries which drain the Lower Carboniferous silicicastic rocks.

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MORPHOLOGY AND CURRENT DISTRIBUTION OF THE LESSER ANTILLES FOREARC SEDIMENTS: IMPLICATION FOR PALEO-SEISMIC RECORDS

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The Lesser Antilles arc spreads over 800 km from the Greater Antilles islands to the South American coastline and results from the subduction of the North and South American plates below the Caribbean plate, at a rate of 2 cm/yr. In northern Martinique, the arc is split in two island alignments, characterized by two distinct sedimentary environments. The first environment corresponds to the inner active volcanic arc, where the main active volcanoes of Guadeloupe and Montserrat are located. The second one is the outer arc, made of old extinct volcanic complexes, now abraded and covered by large Plio-Quaternary submarine carbonate platforms developed around the islands.

Unlike many other subduction areas, the seismic activity is low in this arc and the earthquake catalog is short, with the earliest records dating back to the first European settlement in mid 17th century. Only two large destructive earthquakes where reported during this period, the Mw 8, 1839 and the Mw 8.5, 1843 earthquakes in Martinique and Guadeloupe, respectively. Both earthquakes destroyed the islands' main cities (Fort de France, Pointe-à-Pitre).

The CASEIS oceanographic cruise (2016, DOI 10.17600/16001800) aims to build a paleoseismological record based on earthquake-triggered turbidites. This study focuses on constraining the distribution and sources of the forearc sediments to bring new information on the sediment transfer paths and pro-cesses and the external forcings such as climate and active tectonics.

During the cruise, we acquired new bathymetric, backscatter and chirp data. Combined with older data, they allowed to perform a detailed morpho-sedimentary analysis. We highlight two distinct areas governed by different transfer modes on the two sides of the arc-perpendicular Désirade normal fault. North of this fault, the forearc is characterized by a rough, ~5000 m-high and up to 20°-steep slope with several basins at its toe. The basins are fed by the arc platform sediment through canyons developed on the substratum, and by submarine landslides originated on the backlimb of accretionary prism folds.

South of the Désirade fault, from Guadeloupe to Ste Lucia, all the islands are drained mostly towards the Martinique basin and in two other smaller basins by channels developing on a gentle slope (~2.5°) and affected by several normal faults. The Martinique basin is also supplied by a network of gullies coming from the accretionary prism. The flanks of each channel have undergone many gravitational collapses which seem to be quite old because of their sedimentary cover. The slope is gently undulated, implying the presence of sediment waves, creeping, or both.

Sedimentary processes along the Lesser Antilles arc appear to be driven by both climatic and active tectonics forcing. Particularly, the Desirade and Martinique basins are linked to the shelf and could contain a mixed record. However, the sedimentary record of the numerous basins isolated from direct terrestrial input, is likely dominated by earthquake-driven sedimentary processes. The joint investigation of both types of basins shows therefore a strong potential for paleo-seismic studies.

LONG TERM RECURRENCE OF DEEPLY PONDED THICK HOMOGENITES IN LESSER ANTILLES FOREARC (CASEIS CAMPAIGN): IMPRINT OF STRONGEST SUBDUCTION EARTHQUAKES AND ASSOCIATED TSUNAMIS?

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The Lesser Antilles arc spreads on 800 km from the Greater Antilles islands to the South American coastline and results from the subduction of the North and South American plates below the Caribbean plate, at a rate of 2 cm/yr. Since the beginning of the instrumental period, the associated seismic activity has been relatively low. The earthquake catalog began with the first European settlement in mid-17th century, and only two large damaging earthquakes were reported during this period, the Mw 8, 1839 and the Mw 8.5, 1843 earthquakes respectively in Martinique and Guadeloupe. Both earthquakes destroyed the islands' main cities. However, these earthquakes' estimated magnitudes are lower than the ones from other subduction areas as for the recent Sumatra earthquake (2004, Mw = 9.3) and Tohoku-oki earthquake (2011, Mw = 9.0). While paleo-seismicity related to intra-arc, surface-reaching, active faults can be investigated through reefal platforms rupturing and detailed bottom geophysical imaging, the detection of possible deep subduction earthquakes and their time-distribution remains a challenge. One of the main purpose of The CASEIS Campaign (May/July 2016, DOI 10.17600/16001800) on board R/V POURQUOI PAS? was thus to detect and characterize deep paleoseismic markers and to outline the widespread major events. It was dedicated to the northern half of the Lesser Antilles Arc and more precisely to the forearc realm, from the eastern slope of volcanic islands to the deformation front of the associated Barbados accretionary complex. Beside structural investigations, a sedimentological survey was achieved, based on very high resolution seismic imaging (3.5 kHz), multibeam mapping, and giant piston coring (CALYPSO device). We investigated several basins within the forearc realm, with different tectonic origins at about 5 000 to 6000 m water depth. They display several up to 3 m-thick acoustically transparent layers which are studied through up to 28 m-long cores. In addition to shipboard MSCL logging, the layering, composition, and texture of several selected cores have been investigated, as a first step, through XRF profiles and laser microgranulometry. Radiocarbon dating is in process, performed on planktonic foraminifera. First post-cruise detailed analyses have been done on 26 m-long, Core CAS16-14PC, from the La Désirade basin, and then extended to other sites which display several occurrences of such layers. Based on all parameters and 3.5 kHz profiles, correlations could be established between separated sites, including thick gravity reworking events identified as "turbidites + homogenites" with an up to 5 m thickness. As in other similar settings submitted to large earthquakes and/or tsunamis, we tentatively interpret them as markers of major earthquakes, both because of their sedimentological specificities and of their widespread distribution (at least in the northern half of the arc). With respect to known hemipelagic sedimentation rates in the studied area, these events should have along term (few millennia) recurrence, and their relationship with deep subduction rupturing (megathrust) is discussed. Results are compared with data from within the arc (former GWADASEIS Campaign, DOI 10.17600/9020020).

FACIES MOSAIC DISTRIBUTION OF AN UPPER JURASSIC SHALLOW CARBONATE RAMP REVEALED AFTER EXTENSIVE FIELD WORK ANALYSIS (HIGUERUELAS FM., NE SPAIN)

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The internal facies and sedimentary architecture of an Upper Jurassic inner carbonate ramp was reconstructed after the analysis and correlation of 14 logs located south of Zaragoza (northeast Spain). The studied interval is 10-16 m thick and belongs to the uppermost part of the Higueruelas Formation, which is considered an excellent analogue of certain hydrocarbon carbonate reservoirs (e.g. Arab Formation, Persian Gulf). Facies analysis across the 1 x 2 km study area resulted in the definition of 6 facies and 12 subfacies, based on texture and main skeletal and non-skeletal components. These facies record the transition from intertidal flat, sheltered lagoon, backshoal and local subtidal pond environments. The backshoal environment is represented by peloidal-dominated facies (packstone to grainstone). This facies represents sediment reworked from oolitic-peloidal shoals. Lagoon environment includes oncolitic, stromatoporoid and oncolitic-stromatoporoid facies (wackestone to packstone). The oncolitic facies is characterized by the abundance of up to 5 cm-size irregular oncoids which alternate microbial and micritic laminae, with variable proportions of peloids, ooids and bioclasts. It corresponds to inner lagoon areas, with long low-energy periods favoring microbial growth alternating with short high-energy episodes, when forming micritic laminae. Stromatoporoids facies presents variable proportions of both in situ and reworked stromatoporoids, with frequent presence of corals and chaetetids. This facies occurs in different positions within the lagoon, and grades laterally to oncolitic-stromatoporoid facies, characterized by up to 3 cm-size well rounded to irregular oncoids and fragments of stromatoporoids. Intertidal flat environment is represented by fenestral porosity facies (mudstone to grainstone). This facies occasionally presents stromatolitic structures, which suggests microbial activity. Pond facies corresponds to gastropods-oncolitic packstone to grainstone facies, sometimes associated with marls, characterized by the predominance of gastropods and oncoids. It is laterally related to intertidal and backshoal facies.

Detailed mapping of facies and bounding surfaces across the entire study area have allowed document 7 sedimentary episodes that as a whole reflect a shallowing upward trend, from lagoon or backshoal to intertidal environments. The spatial relationships of facies in the platform reflects a mosaic distribution, instead of facies belts. In particular, stromatoporoid, fenestral porosity and gastropods-oncolitic facies clearly show a patchy distribution, being facies patches more than 100 m in lateral extension.

Sedimentological analysis at detailed scale reveals that caution must be taken into account when performing facies correlations at kilometer scale. Facies mosaic distribution obtained in this work pro-vides useful tools for more precise reconstructions of depositional heterogeneities.

CARBONATE-TO-CLASTIC SEDIMENT DYNAMICS IN A HIGH-RELIEF SUPRA-DETACHMENT BASINCONTINENTAL TO MARINE DEPOSITION IN THE BANDAR JISSAH BASIN, NE OMAN

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A close relation between fault movement and sedimentary stacking is evident from the tectonostratigraphic signature of the mostly Eocene Bandar Jissah Basin, near Muscat in the Sultanate of Oman. The basin evolved above a major extensional detachment linked to extensional collapse following the Late Cretaceous Oman ophiolite emplacement. The basin infill is exposed along excellent, kilometer-scale cliffs, revealing a ~1,5 km thick sedimentary succession in the hanging wall of a major segmented boundary fault locating roll-over folds. The Paleocene (?) to Eocene basin fill records extensional faulting episodes along two hard-linked, large normal faults striking NW and NE, respectively. Initial high input of coarse clastic material is considered a response to basin-bounding fault activity in a continental setting. A coarse conglomerate was deposited near the fault escarpment during the early stage of faulting, and grain size reduction away from the fault reflects increased distality. Conglomerates proximal to the fault represent alluvial fan and braid-plain deposits with scattered patches of preserved soil profiles that are otherwise eroded. Braid-plain deposits dominate with greater distance from the fault, while soil profiles increase in thickness and lateral extent. Sediment maturity and palaeocurrent data suggest a localized sediment source, presumably a canyon cut across the boundary fault. A thin transgressive lag marks the boundary between continental conglomerates and mixed carbonate/siliciclastic sandstones formed in a submarine setting. These mixed deposits are considered to represent an extensional faulting climax, where tectonic subsidence outpaced sedimentary input, thus effectively drowning most of of the basin. Sediment supply caught up with tectonic subsidence during the late stage of this episode, as evident by a shallowing-upward signature in the carbonate/siliciclastic sandstones, culminating with development of carbonate reefs in the uppermost stratigraphic level. Continued base-level fall led to deposition of soils on top of the carbonates. Thereafter, a deepening-upward trend suggest renewed extensional fault activity mainly on the NE-trending, southern fault segment, with a second extensional faulting climax indicated by a 500 m thick grain-stone to marly limestone succession. Limited siliciclastic input in this succession suggests the basin was detached from the sediment source represented by the nearby footwall basement (core complex), and that the aforementioned feeder-canyon was abandoned as a sediment point-source. Instead, debris from shallow marine carbonate production interfingered with small fans sourced from spatially limited footwall catchments. The marine to continental transition in the Bandar Jissah Basin highlights the delicate balance between sedimentary base-level and fault activity along basin bounding faults, which results in significant spatial and vertical facies contrasts.

LITHOLOGY AND STRATIGRAPHY OF DEVON-CARBON DEPOSITS OF LARGE KARATAUH AS THE STANDARDS OF OIL AND GAS DEPOSITS OF THE CASPIAN DEPRESSION

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In Big Karatau (Southern Kazakhstan), the Devonian-Carboniferous deposits are developed in the interval from the Frasnian to the Bashkirian stage and extend to the surface of the day. In some well-naked and continuous sections, their thickness exceeds 4000 m. Similar carbonate deposits of the Caspian depression, according to modern paleogeographic patterns, accumulated in fairly close conditions. However, the roof of such deposits in the Caspian Basin is submerged to a depth of more than 2.5 km. In this regard, the well-naked carbonate rocks of the Late Devonian and the Early Carboniferous of the Big Karatau can serve as lithological and stratigraphic analogs of those of the Caspian depression. Consequently, the results of detailed lithological and biostratigraphic study and age interpretation of carbonate sections in Karatau can be confidently extended to similar sections of the Caspian depression. This has great scientific and practical significance for studying the conditions for the formation and forecast of new promising oil and gas bearing sites.

The rocks of the Big Karatau are represented by the full spectrum of the facies of the carbonate platform: from the facies of the deep-water basin, to the margin of the carbonate platform and its inner zone as the shelf lagoon and the tidal plain of the shallow water. In continuous and well-naked incisions, large flood events were documented, i.e. Sea transgression or sea level rise and shallowing, i.e. Regression with a sharp drop in sea level. With facies changes are associated changes in the lithological composition and reservoir properties of rocks, which allowed with the necessary accuracy to perform lithostratigraphic correlation of sediments in sections of regions quite far from each other.

FAULT-RELATED DOLOMITES ASSOCIATED WITH TRANSTENSIONAL REGIMES: A COMPARATIVE STUDIES

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Fault-related dolomites are studied at three different selected locations worldwide (Spain, Pakistan and Malaysia) to understand the diagenetic processes in transtensional tectonic settings, which resulted into unique set of geo-bodies. Striking similarities are observed at these locations, which include: (i) various dolomite phases representing multiple dolomitization events, (ii) Post-dolomite calcite crystallisation, and (iii) relatively elevated fluid temperature in the final stages of dolomitization and calcite precipitation. O/C isotope signatures indicate a hot and deep seated source for dolomitizing fluids. The diagenetic history reflects repeated periods of fracturing, fluid expulsion, dissolution and cementation. In addition, dolomite cement is mostly restricted to faults and fractures, whereas replacive dolomite occur away from the main fault. Furthermore, replacive dolomite exhibit well developed crystal geometry, in contrast to the dolomite cement phase. This in turn affects porosity and permeability of these dolomite phases, where replacive dolomite exhibit relatively high porosity and permeability values as compared to dolomite cement phase.

SEQUENCE-PALEOGEOGRAPHY AND COAL ACCUMULATION OF THE EARLY-MIDDLE JURASSIC IN CENTRAL QILIAN MOUNTAIN BELT (MULI BASIN), QINGHAI PROVINCE, NW CHINA

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The Muli Basin in the Qinghai Province, located on the Tibetan Plateau, is a Jurassic coal-bearing basin, and is an important area for coal production in China. Recent explorations have revealed the presence of unconventional types of gases such as coalbed methane (CBM) and gas hydrates. In this study, the sedimentology, sequence stratigraphy and lithofacies paleogeography of this basin were investigated on the basis of data from outcrop and borehole sections. The succession of the Early-Middle Jurassic, including the Reshui, Muli and Jiangcang Formations, is subdivided into 4 third-order sequences, and basin-wide paleogeographical maps under the sequence stratigraphic framework were constructed. The Reshui Formation (S1) is composed mainly of mudstones, siltstones, sandstones and coal seams, which were formed in braided fluvial, braided delta and shallow lacustrine depositional systems. The Muli Formation (S2) consists of mudstones, siltstones, sandstones and mineable coal seams, which were formed in braided fluvial, deltaic plain, delta front and shallow lacustrine depositional systems. The Lower Member of Jiangcang Formation (S3) consists mainly of mudstones, siltstones, fine-coarse sandstones and coals, which were formed in deltaic plain, delta front and shallow lacustrine depositional systems. The Upper Member of Jiangcang Formation (S4) consists mainly of mudstones, siltstones, fine sandstones, shale with thin-bedded oil shale, which were formed in the braided fluvial delta and lacustrine depositional systems. In the Early-Middle Jurassic period, the Muli Basin experienced an evolution from a braided fluvial to braided fluvial delta, then to a lacustrine system, and it showed a gradual deepening process. Thick coal seams were primarily developed in delta plain environment under the control of the balance between the rate of accommodation generation and rate of peat accumulation.

PETROLOGY, GEOCHEMISTRY AND PALEOENVIRONMENTAL SIGNIFICANCE OF THE END-PERMIAN COALS IN SW CHINA

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Non-marine terrestrial coal measures of the Late Permian are developed in the Xuanwei area of Yunan Province (SW China). The C1 coal, which contains the B1, B2, B3 sub-seams in descending order, lies at the uppermost of the Xuanwei Formation (Lopingian). The proximal nature of the C1 coal to the PTB (Permian and Triassic Boundary) has been established by a combination of biostratigraphic, geochemical and lithological evidences.

Coal petrology studies have revealed the upward increasing trend of the inertinite abundance in the latest Permian coals and this could imply that the Late Permian peatland was suffered from frequent wildfires. A model-based calculation suggests that the atmospheric O_2 levels near the PTB could reach 28%. Quartz is the dominant mineral in the C1 coal, while kaolinite is the dominant mineral in roofs, floors and partings of the C1 coal seam. Hexagonal β-quartz in desmocollinite, abundant perfect hexagonal bipyramid quartz and sharp bipyramid anatase show that the C1 coal was also influenced by volcanic activity during development of the peat swamp.

Different sulfur fractions of low sulfur (average 0.11%) coals from the latest Permian coal in Xuanwei area were analyzed isotopically at a high vertical resolution. Sorg (organic sulfur) accounts for 87% of the total sulfur content on average, while Spy (pyritic sulfur) is very low, accounting for 13%, and relatively constant throughout the profile except for some insignificant additions in clay-rich layers. The $\delta^{34}S_{org}$ values have a relatively narrow range, from +1.5 ‰ to +7.6 ‰, and the stratigraphically lower coal (B3) has $\delta^{34}S_{org}$ values around +4 ‰ while the stratigraphically higher coal (B2), which is closer to the Permian–Triassic boundary, has clearly higher $\delta^{34}S_{org}$ values, ranging from +5.3 to +7.6 ‰. This change is most likely due to increased marine sulfate aerosol inputs into the coal-forming peatland caused by coastline retreat during Late Permian transgression.

The organic carbon isotopes of these latest Permian coals were analyzed, and the results showed that the carbon isotope profile depicts an upward lightening trend throughout the whole Late Permian (Lopingian), and in the uppermost few seams, a negative excursion with magnitude of about -5.0 ‰ (-25 ‰ to -30 ‰) is evident. These phenomena are consistent with the observations from other reported marine and terrestrial PTB sections. It has been generally accepted that the PTB event was a protracted event with various causes including volcanic eruption, release of methane, baking or burning the coal measures in the major coal basins.

However, coal is the product of the peatland, which is the direct evidence of the terrestrial ecosystem. Coal persisted after the onset of the negative excursion, suggesting the causes of the carbon cycle perturbation did not wipe out the terrestrial productivity immediately. Comparatively, the major marine fauna extinction started at the beginning of the carbon isotopic excursion near the PTB in marine sections. It is thus suggested that terrestrial ecosystem was more resilient towards the carbon cycle perturbation.

DIAGENESIS IN TIGHT SANDSTONES AND ITS INFLUENCE ON RESERVOIR QUALITY: A CASE STUDY OF THE SHANXI FORMATION IN THE NORTHEASTERN ORDOS BASIN, CHINA

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Reservoir quality is critical in tight gas exploration. A systematic study of the petrological, petrophysical and diagenetic characteristics of the Shanxi Formation tight sandstones in the northeastern Ordos Basin in China was undertaken to characterize pore system of the tight sandstones and recognize the distribution of high-quality reservoirs. The results suggest that the Shanxi Formation tight sandstone has low compositional and moderate textural maturity, with its porosity ranging from 0.7% to 11.8% (average 5.97%) and permeability ranging from 0.001 mD to 2.77 mD (average 0.36 mD). In addition, thin-section and SEM observations suggest that the sandstone is dominated by secondary dissolution pores, primary intergranular pores as well as microfractures, and has undergone compaction, cementation, and dissolution. Diagenetic minerals, such as carbonate cements, authigenic quartzs, clay minerals, and dissolved feldspars, are identified in the tight sandstones. Fluid inclusions are observed in healed microfractures of quartz grains and in quartz overgrowths, while the homogenization temperatures of fluid inclusions in healed microfractures and in quartz overgrowth are in the ranges of 92.8-179.1 °C (average 134.8 °C) and 104.7-169.1 °C (average 145.69 °C), respectively. Authigenic kaolinites are sourced from the process of K-feldspar dissolution, authigenic illites are sourced from transformation of smectite and kaolinite, and sources for quartz cements include mineral alteration and pressure dissolution. A selective dissolution of K-feldspars in the presence of carbonate minerals is observed in the Shanxi Formation tight sandstones due to the different equilibrium constants of carbonate minerals and K-feldspar leaching, and this results in a large amount of dissolution pores associated with K-feldspar. Reservoir quality of the Shanxi Formation tight sandstones is greatly influenced by diagenesis, as compaction and cementation are responsible for the loss of porosity while dissolution accounts for the enhancement of secondary porosity. High-quality reservoirs in the Shanxi Formation potentially develop in sandstones adjacent to source rocks. The results of this study can be used to understand the distribution of "sweetpot" reservoirs and predict favorable exploration targets in tight gas sandstones in similar geological settings, thus reduce the exploration risk.

PORE STRUCTURE CHARACTERIZATION OF TIGHT GAS SANDSTONES USING NMR AND IPMI EXPERIMENTS

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Tight gas has now become an important component of unconventional resources, and pore structure of tight gas sandstone has become a research focus. Laboratory experiments including routine petrophysical measurement, thin section and scanning electron microscopy (SEM) observations, incremental pressure mercury injection (IPMI) and nuclear magnetic resonance (NMR) were conducted to systematically characterize the pore structure of tight sandstone from Lower Shihezi Formation of Permian (P2x) in the northeastern Ordos Basin, China. The influences of pore types, pore size distribution and fractal characteristics on reservoir quality of tight sandstones are also investigated. Results show that the studied tight sandstones generally possess poor quality and complex pore structure. The porosities and permeabilities range from 4.08% to 17.56% (average 9.22%) and from 0.05 to 16.66 mD (average 2.49 mD), respectively. Five pore types were observed in thin section and SEM images: primary intergranular pores, intergranular dissolution pores, intragranular dissolution pores, micropores within clay aggregates, and microfractures. The pore throats are mainly hairy/fibrous, inhibiting the connectivity between pores. Three types of pore structures were identified in the mercury-injection curves and pore size distribution curves from the IPMI experiment and in the T2 relaxation time spectrum obtained by NMR. Both experiments yielded consistent classifications, and their combination was necessary to analyze the pore structure effectively. In general, permeability and porosity are positively related and depend on pore types. Large numbers of small pores confer high storage capacity, whereas small numbers of larger pores improve the flow capability. In the high porosity–permeability zone, the larger pores also determine the storage capacity. The P2x tight sandstone is fractal, and macropores are more heterogeneous while micropores are more homogeneous. The fractal dimensions of macropores are good indicators of the reservoir quality of the P2x tight sandstone as larger fractal dimension values of macropores indicate poor reservoir quality.

LINKING SUBAERIAL EXPOSURES TO PALEOENVIRONMENTS AND PALEOCLIMATES: RECORDS FROM THE VALDORRIA CARBONATE PLATFORM, NORTHERN SPAIN

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Glacio-eustatic driven cyclothems are well recorded in Late Paleozoic deposits and have been reported worldwide. Subaerial exposure surfaces developing at the top of cyclothems linked to sea-level lowstands are typical features in these deposits. The study of subaerial exposure not only allows to reconstruct the diagenetic evolution of a system, but also provides important information about the paleoclimate. Subaerial exposure horizons from the Valdorria carbonate platform, an isolated system in the Cantabrian Mountains, northern Spain, were explored with the goal to constrain paleoclimatic changes through time.

The platform developed during the Bashkirian (Pennsylvanian) in the Variscan foreland basin, which is nowadays known as the Cantabrian Zone. The platform was buried by pelagic sediments of the San Emiliano Formation prior to being exhumed to surface by alpine tectonism, which consequently exposed a lateral and vertical transect of the platform. Subaerial exposure surfaces have been identified predominantly as immature dissolution surfaces, and mature karstic and/or pedogenic surfaces. Observed eogenetic features of interest range from marine deposition and cementation to meteoric dissolution and cementation. Mesogenetic and telogenetic features are prominent as well.

Various cement generations were identified using transmitted light and optical cathodoluminescence petrography. In situ elemental geochemical analyses of Ca, Mg, Fe, Mn, and Sr have been acquired for the various carbonate cements to confirm the paragenetic sequence of the diagenetic realms. For calcite, $\delta^{18}O$ isotopes virtually show the different rock-water interaction affecting karstic and calcretic features, while $\delta^{13}C$ isotopes are mostly skewed due burial diagenesis. On the other hand, isotopes also confirm that three different phases of dolomitization occurred throughout the growing and burying of the carbonate platform.

The interpretations of a climatic evolution of the platform are portrayed by morphological observations and mineralogical identification. A first major emersion surface that displays a thick calcrete profile, which possesses illite-smectite (reminiscent of smectite) and lacks kaolinite, records a semi-arid climate during the respective stage of platform development. A second and younger major emersion surface shows similar clay mineralogy and a thin calcrete profile that displays a distinct red matrix, which suggests a transformation to an arid climate. Meanwhile, the youngest major emersion surface found at the platform-top exhibits an extensive karstic system with kaolinite present throughout, which indicates that the platform evolved to a wet climate before drowning. The three mentioned subaerial exposures exhibit siliciclastic material that has evidently been derived from an extrinsic source. Incompatible trace element geochemistry suggests an intermediate volcanic-arc derived source for the siliciclastic input into the carbonate system. Moreover, $^{87}Sr/^{86}Sr$ isotopes of the calcite of the pedogenic profiles suggest that calcium was largely derived from aeolian dust prior to undergoing calcification.

Linking the petrographic and mineralogical framework to geochemistry has provided a paragenetic relationship related to the relative timing of diagenetic and pedogenic events, and subsequently to how the past environments and climates of the platform evolved overall. This approach has proved to be a powerful tool for paleoclimate reconstruction.

CLINOPTILOLITE WITHIN UPPER JURASSIC MUDSTONES OF THE CENTRAL RUSSIA AS INDIRECT CONSEQUENCE OF HIGH SEA SURFACE BIOPRODUCTIVITY

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The moderate to intensive zeolitization, expressed by impregnation of mudrocks by small euhedral crystals of the minerals, belonging to clinoptilolite-heulandite group, is observed in the Upper Jurassic of the Central Russia. The clinoptilolitization does not develop within a local spots or thin bands that could be attributed to a “camouflage” pyroclastics, and any morphological traces of volcanic ash particles are not detected by optical methods and SEM. Commonly the clinoptilolitization is covered a relatively large stratigraphical intervals, such as Upper Oxfordian “Kolomenskoe Formation” of *Alternoides* ammonite Zone, typically contained thin black shales in the lower portion, or Middle Volgian “Kashpir Oil Shale” corresponding to *Panderi* Zone.

The both studied intervals are built up of silty calcareous mudstones, bearing shell detritus, muddy intraclasts, glauconitic and phosphatic pellets, which is varying in size from the silt to fine sand. Terrigenous silt is quite mature in composition and represented by quartz, orthoclase and flakes of micas, identified by XRD as a degraded illite. All of the facies could be attributed to an outer shelf zone, subjected to only a weakened storm activity. Stratigraphical proximity to black-shale lithofacies indicates the depositional environments prone to anoxiaand accumulation of autochthonous OM. The both studied intervals show bundles of discontinuity surfaces, resulted from episodes of non-deposition, which is marked by glauconitization of burrows, phosphate and pyritic nodules, concentrations of belemnite rostra and ammonite shells.

In the Middle Volgian mudstones the clinoptilolite are quite small for optical resolution, but its presence invariably detected by XRD-method within a finest clay fractions (< 0.001 mm). It is remarkable, that some glauconitic pellets and phosphate nodules occasionally show a remnants of radiolarian microstructure, accented by pyrite. So it is reasonable to assume that radiolarian siliceous material could be a source of the silica, required for the building a Si-rich crystalline structure of clinoptilolite. The unlimited storage of Cacations could be provided by calcareous biogenic material, while abiogenic aluminum could be extracted from a dispersed terrigenous suspension, rich in of Fe-Al oxides-hydroxides.

In a contrary, the mudstones of Kolomenskoe Formation are densely impregnated by coarser clinoptilolite. Petrographical observations show a distinct secondary moldic microporosity, caused apparently by selective dissolution of radiolarian shells, and the majority of voids are distorted and elongated due to compaction. Crusts of a radiaxial clinoptilolite covers the walls, and the druses of crystals are filling the centres of the voids.

Thus we suggest that the clinoptilolite was formed in initial stages of compaction during burial diagenesis as a result of dissolution of radiolarian siliceous shells, and partly, of biogenic carbonates. This processes have been stimulated by a decomposition of organic matter, and the availability of abiogenic aluminium have been provided. Finally, the clinoptilolite in the mudstones, being a direct product of the radiolarian degradation, can be assumed as an indirect proxy of the high sea surface bioproductivity in the distal portions of the Late Jurassic marine basins.

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SEQUENCE STRATIGRAPHY, LITHOFACIES PALEOGEOGRAPHY AND COAL ACCUMULATION OF A PARALIC GENTLE SLOPE BASIN: A CASE STUDY FROM WUWEI BASIN

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The Wuwei Basin is one of the major coal-bearing and oil-gas basins in Northwest China. Based on the study of sedimentary characteristics from outcrops and boreholes, the Carboniferous to early Permian sequence stratigraphic framework of Wuwei Basin has been established, and paleogeographic maps based on third-order sequences have been constructed. The coal accumulation model, the sequence framework and the coal accumulation model in the sequence stratigraphic framework were analysed. According to lithofacies characteristics and lithofacies assemblage types, the marine sedimentary environments and marine-continental transitional sedimentary environments have been identified and divided into the coastal, carbonate platform, barrier island, lagoon, tidal flat, delta and estuary in the Carboniferous to early Permian. In the Carboniferous to early Permian coal measures, the key sequence bounding surfaces, such as the regional unconformity, the basal surface of incised valley fills, the colour abrupt change surface and the transgression direction shift surface, have been identified. The sequence stratigraphic framework of the Wuwei Basin shows that the strata of Carboniferous to early Permian consists of seven third-order sequences, which lasted about 63.4 Ma. The paleogeographic framework of the study area is constructed using the dominant sedimentary facies method. Based on the principle of coal thickness and paleogeographic maps, the most favourable coal accumulation environments are tidal flat and barrier-lagoon, followed by delta. The main coal accumulation centre is situated in the Yingpan Sag in the south of the basin, followed by the Ermahu Sag in the north of the basin. The sequence stratigraphic framework controls the vertical development of the coal seams, while the lithofacies paleogeographic units influence the lateral development of the coal seams. Tidal flat, barrier– lagoon and delta in the late TST and early HST are the most favourable coal accumulation paleogeographic units.

A NEW DISCOVERY OF THE PALEOGENE LACUSTRINE HYPERPYCNAL FLOW IN DONGYING DEPRESSION

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As an important oil gas reservior, deepwater gravity flow depositon has become common focus of current academic and oil gas industry. A type of sand which is different from sandy debris flow deposition and slumped turbidite in the Middle of Es3 Dongying Depression. The rasied surrounding mountains, abundanted clastic sources and frequently rivers injection provides the conditions for the deposit of sediment gravity flows. Its sedimentary characteristics consists of a series of basal coarsening-up unit and top finningup unit. Erosional surface exists between inversely graded unit and normal graded unit. Through the core observation and thin section analysis, rock association is thought to be formed by the hyperpcnal flow in the background of the deep lake. Hyperpycnites differ from other turbidites because of their well-developed inversely graded facies and intrasequence erosional contacts. A basal coarsening-up unit deposited during the waxing period of dischage and a top fining-up unit deposited during the waning period of discharge. The occurrence of inversely-normal graded unit represents event depositional cycle. It is divided into three types of sedimentary facies: the hyperpycnal flow channel fill facies, the hyperpycnal flow levee and the hyperpycnal flow frontal lobe. Channel fill facies with the characteristics of coarse-graind sandstones, basal erosional surfaces and finning-up unit. Levee with the characteristics of fine-grain sand, silt and clay, inversely-normal graded unit, thin sandmud interbed and abrupt interface between inversely graded unit and normal graded unit. Frontal lobe with the characteristics of inversely-normal graded unit but, inversely graded unit is not too developed. The discovery of the Middle Es3 hyperpycnite in Dongying Depression not only provide a paradigm of hyperpycnal flow depositon in continental lacustrine basin, but also has theoretical and practical significance for the study of deepwater sand bodies, resevoir prediction and oil gas exploration.

GLOBAL CARBON CYCLE AND CLIMATE CHANGE INTERACTIONS DURING THE NEOPROTEROZOIC

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Carbon isotope excursions have long been associated with glaciation during the Neoproterozoic, but teasing apart cause from effect is difficult. One model invokes the existence of a large 'dissolved' organic carbon reservoir in the deeper parts of the world's oceans, which when oxidized can cause negative carbon isotope excursions, but once exhausted could leave the Earth vulnerable to extreme climate change. One test of this model would be to establish whether carbon isotope events and glacial onset are temporally related. In the case of low-latitude Cryogenian glaciations, which began at about 715 Ma, the pre-glacial 'Garvellach' (previously named'Islay') negative C-isotope anomaly clearly preceded the onset of low-latitude early Cryogenian 'Sturtian' glaciation in Scotland (and elsewhere). In this presentation, an apparently transitional succession on Garbh Eileach in Scotland and related isotope data will be discussed. The late Cryogenian

'Marinoan' glaciation is preceded by the extremely negative 'Trezona' anomaly, which recovers to normal values during the transition to low-latitude glaciation in Australia. The relative timing of isotopic and climatic events is consistent with the exhaustion of a vast organic carbon reservoir due to excess oxidant production. Although it is widely thought that increased organic burial would counteract the effect of DOC oxidation on ocean carbon isotope composition, this buffering effect is more consistent in cases of oxygensensitive oxidation weathering of a terrestrially-based organic carbon reservoir, while low C-isotope values do not necessarily imply lower rates of organic burial. Other negative excursions characterize much of the Neoproterozoic Eon, with the earliest known anomalies in rocks dated at ~925 Ma, but their relationship to climate change is less well constrained. Several researchers consider that the c. 580 Ma Gaskiers glaciation coincided with a relatively small, negative C isotope excursion in the Yangtze Gorges area of South China. This may explain why the Gaskiers glaciation was of only regional importance, because oxidation of the DOC reservoir acts as a negative feedback on atmospheric greenhouse gas levels, thus reversing cooling, until exhausted. The end-Ediacaran Shuram anomaly, however, is much larger, but apparently unassociated with glaciation, although there are several well-described glaciogenic deposits around the world, e.g. on the North China craton, that could have an Ediacaran-Cambrian age. The recovery from the Shuram anomaly is associated with global ocean oxygenation, which is also consistent with oxidation of a DOC reservoir because excess oxidant production would no longer be buffered once the reservoir became exhausted. Anomalous carbon isotope excursions, both positive and negative, bracket an extraordinary interval of climatic and environmental perturbations, and so a plausible explanation of their origins will surely help towards a more complete understanding of the Proterozoic-Phanerozoic Earth system transition.

HINDERING SETTLING AS A GENERIC PROCESS TO TRIGGER TURBIDITY CURRENTS

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Turbidity current deposits form some of the largest sedimentary bodies on our planet. Large stacks of turbidites and intercalated hemipelagites are a powerful sedimentary archive that enable reconstructions of palaeoclimate and paleoenvironments. However, to link local turbidite deposits to regional or global controls such as climate, a detailed understanding of the mechanisms by which turbidity currents are driven and triggered is required. As yet, an unifying process-based understanding of turbidity currents triggers is still being developed. Key to the initiation of turbidity currents and of the sediment transfer to the deep sea is the generation of highly-concentrated sediment suspensions (i.e. hyperpycnal suspensions) in the sea-water.

Different mechanisms have been proposed to initiate turbidity currents from the suspension of sediment in the water column such as: dilution of submarine landslides, river flood bringing suspended sediment to deltas, sediment suspended by storm-induced wave-action, trawling. Most of these source mechanisms induce sediment suspensions that will settle once the associated turbulence decreases or vanishes.

This settling process is here analytically approached as a Kynch semi-finite problem, where a diluted (i.e. hypopycnal) sediment suspension is continuously fed (e.g. under a river plume). The fall velocity is assumed to be just a function of the local sediment concentration. Here we extended this theory to the hindering regime up to the gel/packing concentration. This allows (1) the evidence of complementary sediment concentrations, i.e. highly contrasted sediment concentrations providing similar fluxes of settling suspended sediments, and hence (2) the study of the evolution of discontinuous steps in the vertical sediment concentration profiles. We are providing a process-based interpretation of how relatively dilute suspensions transform into hyperpycnal layers driven by hindering settling. Considering the necessary conditions to maintain sediment-laden gravity driven flows, we suggest that hindering settling is a fundamental process to generate turbidity currents of both sand and clay rich sediment suspensions.

This generic process of generation of highly-concentrated sediment suspensions and turbidity currents triggering provide realistic interpretations linking to field observations: (1) trawling induced plumes in La Fonera canyon (Catalunian margin), (2) wave action above the Capbreton canyon (Golf of Biscay), (3) tidal modulation of river plume extension in the Bute estuary and (4) flood activity in the Var river and canyon (French Mediterranean margin). The integration of this process in a process-based modelling approach would able to simulate turbidity currents generation and to provide a quantitative link between sediment sources and deeper water turbidites.

PASSIVE MARGIN STRATIGRAPHY FOR NUMERICAL MODELS CALIBRATION: COEFFICIENT OF DIFFUSION MEASUREMENT IN THE OGOOUÉ DELTA (GABON)

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One major and undepreciated point in diffusion process-based stratigraphic modelling is the large range of coefficients of diffusion used to reproduce natural examples without considering their meaning and their validity in term of transport and deposition processes. Most of the time, present-day stratigraphic models are not used as real forward models but more as a tool to make semi-inversion based on a "best-fit" approach to reproduce well-constrained sedimentary systems.

The aim of this work is to consolidate inputs of stratigraphic numerical modelling by calibrations based a natural passive margin deltaic system: the relative small and structurally well delimited Cenozoic post-rift Ogooué Delta in Gabon. From seismic and wells analyses, this system evolves from Paleogene aggrading ramp to a significant deltaic progradation resulting from a major Lower Miocene uplift.

Calculations from high resolution seismic stratigraphy and wells analysis are performed in three steps: (1) measurement of the sand/shale ratio evolution (calibrated on wells) along the depositional profile; (2) restoration of the slope at time of deposition (including correction of differential compaction); (3) calculation of depositional fluxes using a basin-scale age model at the highest time resolution possible and quantification of uncompacted volumes for each time slice and stratigraphic context considered (ratio between accommodation and sedimentation).

Diffusion coefficient values range over one order of magnitude (0.1 to 1 km^2/Ka), that is to say, show less variability than values classically used in published diffusion processed-based stratigraphic modelling (x0.0001 to x10 km^2/Ka). These results also suggest (1) low influence of stratigraphic context on coefficient of diffusion values, (2) higher values of coefficients for the most proximal (shelf) and distal (basin floor) parts of the depositional profile and (2) an increase of coefficient values for clayey dominated facies.

THE LAKE ALBERT RIFT (UGANDA, EAST AFRICAN RIFT SYSTEM): SEDIMENT BUDGET, DEFORMATION, BASIN AND RELIEF EVOLUTION SINCE 17 MA

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The purpose of this study was to quantify the sediment budget, from the catchment to the basin, of an intra-continental rift: the Albertine Rift system located at the northern part of the western branch of the East African Rift. The measurement of deposited volumes of sediments is based on the basin infilling study which consists on both subsurface data and outcrops analysis. The main objectives were (1) to obtain an age model based on onshore mammals biozones and (2) to reconstruct the 3D architecture of the rift using sequence stratigraphy correlations and seismic data interpretation. Deformation evolution of the rift through times is characterized according to seismic interpretation and to the distribution and quantification of the accommodation for several time intervals. Two major unconformities were identified and dated at 6.2 Ma (Uppermost Miocene) and 2.7 Ma (Pliocene-Pleistocene boundary), coeval with major subsidence and climatic changes.

The landforms analysis is based on the characterization, relative dating (geometrical re- lationships with volcanism) and 3D mapping of Ugandan landforms which consist of stepped planation surfaces (etchplains and pediplains) and incised valleys.

We here proposed a seven-steps reconstruction of the deformation-erosion-sedimentation re- lationships of the Lake Albert Basin and its catchments.

- <45 Ma (Lower-Middle Eocene): formation of laterites corresponding to the African Surface during the very humid period of the Lower-Middle Eocene;
- 45-22 Ma (Upper Eocene to Lowermost Miocene): stripping of the African Surface in response of the beginning of the East-African Dome uplift and formation of a pediplain as- sociated to the Atlantic Ocean base level;
- 17-2.7 Ma (Uppermost Lower Miocene to Pliocene): initiation of the Lake Albert Basin around 17 Ma and creation of local base levels (Lake Albert, Edward and George) on which three pediplains tend to adapt;
    - ° 17 Ma-6.2 Ma: "low and diffuse deformation" stage (subsidence rate: 150-200 m/Ma; sedimentation rate 1.3 km3/Ma between 17 and 12 Ma and 0.6 km3/Ma from 12 to 6 Ma) – depocenters location is poorly controlled by fault;
    - ° 6.2 Ma-2.7 Ma: rift stage 1 (subsidence rate: > 500m/Ma up to 600-800 m/Ma; sedimentation rate: 2.4 km^3/Ma) – rifting climax;
- 2.7-0.4 Ma (Lower to Middle Pleistocene): rift stage 2; uplift of the Ruwenzori Mountains and shifting from an alluvial system to a network of bedrock river incisions (subsidence rate: 450 to 250 m/Ma; sedimentation rate: 1.5 km^3/Ma);
- 0.4-0 Ma (Middle to Upper Pleistocene): long wavelength downwarping of the Tanzanian Craton, initiation of the Lake Victoria trough, drainage network inversion and uplift of the present-day Ugandan escarpment.

The sediment budget is successful with, between 17 and 2.7 Ma, an excess of 16 % of up-stream eroded material compared to the sediment volume deposited that can be explained by the chemical erosion prevailing at this period in Central Africa. The significant (60%) opposite difference between 2.7 and 0 Ma may be the consequence of a high sediment supply resulting from the erosion of the uplifted Ruwenzori Mountains.

REPRODUCIBILITY IN CYCLOSTRATIGRAPHY: INITIATING AN INTERCOMPARISON PROJECT

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The study of astronomical climate forcing and the application of cyclostratigraphy have experienced a spectacular growth over the last decades. In the field of cyclostratigraphy a broad range in methodological approaches exist. However, comparative study between the different approaches is lacking. Different cases demand different approaches, but with the growing importance of the field, questions arise about reproducibility, uncertainties and standardization of results. The radioisotopic dating community, in particular, has done far-reaching efforts to improve reproducibility and intercomparison of radioisotopic dates and their errors. To satisfy this need in cyclostratigraphy, we initiate a comparable framework for the community. The aims are to investigate and quantify reproducibility of, and uncertainties related to cyclostratigraphic studies and to provide a platform to discuss the merits and pitfalls of different methodologies, and their applicabilities.

With this poster, we ask the feedback from the community on how to further design this comparative framework in a useful, meaningful and productive manner. In parallel, we would like to discuss how reproducibility should be tested and what uncertainties should stand for in cyclostratigraphy. On the other hand, we intend to trigger interest for a cyclostratigraphic intercomparison project. The intercomparison project will be structured around several “test scenarios”, which are signals to be analyzed by participants that feature state-of-the-art challenges in time-series analysis of geologic signals. All participants would be free to determine their method of choice. However, a handful of criterions will be required for an outcome to be comparable. Participants will be solicited to submit and/or present and describe their solutions to one or several of the “test scenarios” at a common event (e.g. workshop). The lessons learned from the comparison could be reported in a review paper.

The aim of an intercomparison project is not to rank the different methods according to their merits, but to get insight into which specific methods are most suitable for which specific problems, and obtain more information on different sources of uncertainty. As this intercomparison project should be supported by the broader cyclostratigraphic community, we open the floor for suggestions, ideas and practical remarks.

COARSE-GRAINED CARBONATE (HETEROZOAN) DENSITY FLOWS: INFERRED DIFFERENCES WITH SILICICLASTIC COUNTERPARTS BASED ON FIELD OBSERVATIONS

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The occurrence of major sediment density flows has been documented on the Lower Pleistocene distally-steepened heterozoan carbonate ramp of Favignana Island, Italy. Occassionally, large quantities of coarse-grained skeletal remains were transported down-ramp resulting in the deposition of up-to-6-metresthick density flow beds in middle-ramp, ramp-slope and toe-of-slope settings. The progradational succession that makes up the majority of the Favignana carbonate wedge, spanning ca. 450 ± 200 kyr, contains 20 of such density flow beds. This constrains the recurrence period of density flow events at 23 ± 10 kyr. Highquality exposures in abandoned quarries reveal a range of sedimentary structures generated by upper flowregime bedforms including unstable antidunes, chute-and-pools and cyclic steps. Upslope-dipping backsetstratification and composite erosion surfaces are central in the observed stratal geometries. They are believed to reflect the general supercriticality of the carbonate density flows that lie at the origin of the studied beds. In distal settings, such beds are observed to thin from over 4 m thick down to 20 cm over a down-slope distance of only 100 m, which illustrates the low transport efficiency of the coarse-skeletal-debris-transporting flows once the driving force (slope) was removed. In addition, sedimentary structures associated with typically erosional hydraulic-jump-related bedforms are non-erosional over their entire length, reflecting suspended sediment concentrations exceeding a threshold for the uptake of additional material at the base of the flow, a process commonly referred to as ‘hindered erosion’. At high suspended-sediment concentrations, grains no longer settled freely through the water column, but experienced hinder from surrounding particles in suspension. Such ‘hindered settling’ is believed to have created a high-density basal layer, which was the bedform-generating layer in the density flow. In siliciclastic sediment density flows, the critical sediment concentration is commonly assumed to be 9 volume-percent. Such flows generate lamination previously described as ‘spaced stratification’. In carbonate density flows, loaded with highly-irregularly shaped grains with intragranular porosity, the critical concentration probably lies much lower. In addition, interlocking of skeletal grains may result in deviating styles of ‘traction carpet’ sedimentation. High-density layers are prone to travel in the supercritical regime. Upper flowregime sedimentary structures, therefore, could be characteristic for certain coarse-grained carbonate density flow environments. This presentation aims to contribute to the discussion on the similarities and differences between siliciclastic and calciclastic density flows. The CPG-KFUPM Calciturbidite Research Team is currently developing an experimental strategy to shine new light on such poorly understood fundamental differences.

HOW ACTIVE ARE HETEROZOAN CARBONATE RAMPS? INSIGHTS INTO THE DYNAMICS OF SEDIMENT PRODUCTION, TRANSPORT AND PERMANENT DEPOSITION ON THE PLEISTOCENE CARBONATE RAMP OF FAVIGNANA ISLAND, ITALY

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The production of skeletal material by Heterozoan organisms such as coralline red algae, bryozoans, molluscs, echinoderms and benthic foraminifera may result in significant accumulations of ‘cool-water’ carbonates on carbonate ramps. Such systems typically lack (strong) cementation and the formation of reef barriers, and are therefore sensitive to resedimentation. This emphasises the need of integration of biological (production) and physical processes (resedimentation) in the investigation of this type of marine carbonates. This study documents the biological and physical dynamics of the Lower Pleistocene Favignana carbonate ramp, which formed during the Emilian highstand (ca. 1.6-1.1 Ma). Four subenvironments were identified: inner ramp, middle ramp, ramp slope and outer ramp. Resedimentation dynamics were constrained through lithofacies mapping, revealing that bioclastic debris was emplaced either by (1) flow of the entire water column generating subaqueous dune deposits or (2) submerged density flows depositing up-to-several-metresthick beds characterised by antidunes, chute-and-pools and cyclic steps sedimentary structures. These two styles of resedimentation are emphasised by a discriminating microfacies signature, demonstrating that density flow sediment consistently originated from shallower water depths than the material composing subaqueous dune deposits for which in-situ production was more important. Sr-isotope stratigraphy constrains both the recurrence of resedimentation events and the rate of carbonate production. Deposition from density flows occurred about once every 10,000 years, while the recurrence interval of subaqueous dune deposition was of the order of decades to centuries. In addition, the calculated sediment flux during resedimentation events shows that the two styles of resedimentation link to two genetically different types of event: storms and tsunamis. Though the carbonate factory has probably been continuously active throughout its existence, the Favignana carbonate ramp was inactive during 99.9% of the time in terms of sediment transport.

FAULT-GROWTH IMPACTING EARLY-RIFT FLUVIAL DEPOSITS – CARBONIFEROUS BILLEFJORDEN TROUGH, SVALBARD

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Drainage and deposition in early stages of rifting will reflect morphology generated by highly segmented faults. Infill characteristics do not resemble the later architecture of the basin as the distinct halfgraben geometry develops during the later, rift climax phase. Initially isolated small faults (reaching up to tens of m offsets) will partly segment the basin into numerous shallow depocenters mainly located to sites of maximum fault displacement, with intervening higher grounds in gaps and relays between faults. This morphology divides the sedimentary system into (i) erosive or bypass catchments (basin margins and local highs in footwall of faults), (ii) bypass and/or condensation of sedimentary deposits in fault-gaps and relays, and (iii) hanging wall sinks with more complete sedimentary successions. Accordingly, in these shallow relief, fairly low-gradient basins, fault-generated morphology highly impact the drainage in catchments, distribution of accommodation space, type of strata, and facies belts linked to development of sedimentary environments.

In the mid-Late Carboniferous Billefjorden Trough in Central Spitsbergen, early rift deposits allow analyses of three-dimensional rift architecture, capturing fault growth as well as erosion/bypass and deposition of the sedimentary system. Deposits reflect an arid climate, with an initial siliciclastics dominated terrestrial succession encountered in deeper parts of the basin. This continental unit passes upward into paralic and restricted to open marine evaporite-carbonate deposits, of which the changes in basin characteristics reflect competing impact by fault-driven subsidence, sea level variations in the ice house period, and to a lesser degree climate.

At an early basin stage, local variability in sedimentary facies belts attests to the importance of active faults. Axial, basin-scale drainage as well as the distribution of river deposits are adapted to the growth of small faults. This impact can be seen in four ways: Basins in the hangingwall of faults show axial drainage when they act as major sedimentary sinks; Basins in the hangingwall of faults will when filled return to a transverse drainage pattern; Footwall rebound behind faults cause mainly bypass of sediments; Relay ramps between faults funnel/concentrate the drainage system.

The recorded early-rift drainage pattern and fluvial sandstone belt distribution contradicts general rift models, predicting a half-graben sedimentary system divided into smaller fault-bypass sedimentary systems and larger hangingwall dipslope sedimentary systems. Our detailed observations of early synrift deposits inform our understanding of sedimentary systems in evolving tectonic basins. Further, the encountered sedimentary system has a size that is not easily resolved in seismic data.

TECTONIC AND EUSTATIC CONTROLS ON DEPOSITION IN EVAPORITE-CARBONATE DOMINATED RIFT BASIN FILL, BILLEFJORDEN TROUGH, NORWAY

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Major sea level fluctuations in coastal rifts strongly impact depositional realms and their temporal development. Subsidence and rebound caused by faulting competes with eustatic sea-level changes; how can we distinguish one from the other? The fill of the Carboniferous Billefjorden Trough records tens of cycles of ice-age major changes in eustatic sea level. At the same time, faulting provided more than 2 km of accommodation space mainly filled with an evaporite-carbonate succession deposited in arid climate.

This study addresses the following questions:

• Will rapid change in basin floor morphology and basin segmentation impact the sediments with low residence time, such as carbonates and evaporates?

• Can we distinguish the imprint of tectonically-driven sea-level change from the eustatic sea level fluctuations in syn-tectonic deposits of the basin fill?

We discuss two field study examples of fault impact and associated sedimentary successions from the Billefjorden Trough, targeting the tectonic and the eustatic controls on the deposition.

The first example is based in observations along a small fault, providing meter-scale relief on the basin floor, show faulting expressed within a shallow marine to tidal gypsum deposits as hangingwall accommodation space increases. Within the same succession, thickness of open-marine carbonates deposited from the suspension remains the same despite the active faulting. This reflects the nature of carbonate deposition that, as low-energy deposits drape the basin floor morphology across the fault with auniform thickness.

The second example is that of subaerial exposure and dissolution of evaporites (gypsum) during sea level low-stands, which result in formation of carbonate stratiform breccias. The position of breccias is restricted to the footwall of a meso-scale fault with hundreds-meter offset. Structural analysis allows reconstruction of stratigraphic offset along a fault formed by two parallel segments growing and linking with time. A positive correlation between fault displacement maxima and the position of stratiform breccias in the footwall suggests a tectonic control for exposure and related dissolution. In this case selective dissolution occurs along the crest of footwall transverse anticlines, determining a footwall rebound mechanism being responsible for the dissolution.

We conclude that long-lasting eustatic sea-level changes control basin-wide general trends, whereas faults strongly impact spatially limited areas. Fault-driven sea-level changes drive rapid shifts in basin configuration.

FACIES AND STRATIGRAPHIC ANALYSIS OF REEF-DELTA INTERACTIONS DURING THE END OF THE EXORHEISM IN THE NE EBRO BASIN (SPAIN)

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The Sant Martí Xic Formation constitutes the youngest Pyrenean-sourced depositional system within the 1000 m-thick and essentially deltaic Bartonian succession of the NE sector of the Ebro Basin. Its upper boundary records the transition from exorheic to endorheic conditions, a change that becomes permanent through the subsequent infill stages of the south Pyrenean foreland basin.

In the study area, the progradation of deltaic systems towards the south is particularly pronounced during this period, and this leads to a progressive narrowing of the marine basin, coeval with the last stages before the complete disconnection with the ocean at the Gulf of Biscay. As a consequence, the upper part of the succession reflects a constant decrease of accommodation space, and facies changes occur in progressively shorter distances. Documenting these relatively abrupt facies changes, together with the mixed (carbonate-clastic) nature of the system, constitutes the main interest of this study.

The integration of detailed geological mapping (1:10,000 scale), sedimentary logging (1:100) and stratigraphic correlations across a north-south transect of the study area was needed due to the dense cover of vegetation and extensive quaternary and anthropic deposits. The obtained outcrop dataset has allowed analyzing the transition from purely terrestrial to open marine shelf and slope facies associations, passing through a variety of intermediate depositional environments, both for carbonate and clastic deposits, and including the paleofauna and paleoflora that characterizes them.

The most reliable correlation levels, generally corresponding to the carbonate-rich horizons, and associated with major transgressive events, are used as datums. This allows a segmented analysis of the lateral evolution of the stratigraphic units and, consequently, the extraction of main facies transitions and establishment of predictive depositional models. These correlation marker beds evidence an overall thickening of the succession towards the south, show a direct implication of reef development with major thickness variations, and allow studying the characteristics of clastic deposits that accommodate to the reef geometry.

Independently of which evolutionary stage of the deltaic succession is studied, the disposition of successive facies belts shows a consistent NNW-SSE progradation orientation, with a progressive deepening towards the SSE and consequent shifts of the shoreline in the same direction. This local paleogeography is almost perpendicular to the axis of the south Pyrenean foreland basin, which is subparallel to the orogeny and deepens towards the WNW. As a result, the existence of an ENE-WSW oriented gulf / bay is proposed, in an oblique orientation relative to the main basin axis, at least for its northern margin during the uppermost Bartonian.

GEOMORPHIC AND SEDIMENTOLOGIC IMPRINTS OF STORM SURGES ASSOCIATED WITH TYPHOONS DURIAN AND HAIYAN ON COASTLINES OF THE PHILIPPINES

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Typhoons Durian (2006) and Haiyan (2013) generated storm surges of contrasting overwash regimes. Typhoon Durian produced runup overwash, whereas the sites studied for Typhoon Haiyan typify inundation overwash. This study presents a synthesis of our work spanning a range of clastic lithologies and carbonate landscapes that represent the almost full suite of sedimentological heterogeneity on sandy coastal environments in the tropics. At Site 1 on the sheltered siliciclastic coast south of Tacloban the complete inundation overwash of Typhoon Haiyan left a sandy washover deposit of no more than 20 cm thick that starts ~35 m from the high tide line and progressively spreads into a sub-cm thin sand sheet that blankets the pre-Haiyan soil surface up to ~1.6 km inland. Thicker sections of the overwash sand exhibit sharp, depositional contacts, planar stratification, and generally coarsen upward and fine landward. At Site 2 on the mixed clastic-carbonate coast near Basey, the Typhoon Haiyan deposit is generally a thin (< 10cm), massive, poorly sorted, fine sand unit that contains carbonate material including foraminifera and mollusks fragments, and extends over ~350 m inland. At Site 3 on the carbonate coast of Hernani the deposits of Typhoon Haiyan are in stark contrast to sites elsewhere in the Leyte Gulf because the typhoon transported conspicuous coral reef boulders on the reef flat as well as a carbonate sand sheet that draped the coastal plain up to ~300 m inland. Overall, Haiyan's overwash sediments exhibit characteristics that are consistent with other overwash sediments from comparably intense storm surges, but are also observed in recent tsunami deposits. For comparison, we include Site 4 where Typhoon Durian's storm surge occurred on the volcaniclastic coast near Tabaco City in 2006. Durian's surge was only a fraction of the size of Typhoon Haiyan in 2013 but resulted in the breaching of a volcaniclastic barrier spit. Washover fans extending ~120 m inland were found on two major breaching sites. The Durian washover fan deposits exhibit horizontal to sub-horizontal lamination on the front to mid-fan and foreset stratification at the fan terminus. We find that the inundation overwash of Haiyan produced a washover terrace and extensive sand sheets, whereas the runup overwash of Durian produced discrete washover fans and terraces with limited inland extent. However, in areas that experienced similar storm surge conditions, the contrasting physical characteristics and distribution pattern of overwash sediments from Haiyan underscore the influence of local geology, topography, and vegetation.

A LATE HOLOCENE PALEOCLIMATE ARCHIVE FROM AYN-AL-ZARQA IN NORTHERN SYRIA (NORTHERN LEVANT)

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East of the Fertile Croissant in northern Syria, an extended semi-desert (e.g., the Arid Margins) is characterized by the wide occurrence of artesian springs (as mounds), which were exploited by humans since ca. 10,000 years as an active source of water. However, a very limited anthropogenic activity (e.g., nomadism) has been reported from 750 AD onwards, i.e., during the time interval including the Medieval Warm Period (MWP) and the Little Ice Age. The water infiltrated into the calcareous massifs southwards from the Arid Margins, flows through a deep karst system, becoming highly mineralized and rises under pressure by a network of faults to the surface by forming gypsum platforms. Ayn-al-Zarqa, the largest of those, has several mounds and is characterized in the center by a small palustrine system in which thick silty-sandy sediments rich in plant debris were deposited. Here we report the first (very) high-resolution paleoenvironmental sequence (core ZAR6; 10.08 m) from the Arid Margins between 600 and 1400 AD, based on a multi-proxy approach involving sedimentology, palynology and pollen-based climate reconstructions. This new archive has embedded a detailed record of climate variability before and during the MWP, at an unprecedented time resolution (1-2 years). Of utmost interest is the occurrence of moister conditions, as revealed by all proxies, at the entrance of the MWP (i.e., between 900 and 1000 AD). The MWP is characterized by warm and more humid conditions (in contrast to the LIA) with however a low variability of climatic parameters (both in temperature and precipitation) until 1200 AD. This new record therefore makes a crucial step in our knowledge of climate variability in northern Levant, where very sparse records are available to date. This study also illustrates how spring mounds from artesian sources can be used to reconstruct annual to decadal climate variability in semi-desert environments owing to their high sensitivity to rapid climatic changes. In this sense, they complement lacustrine and speleothem archives and may offer valuable new insights for high-resolution paleoclimate studies.

EXPLORING PAST MICROBIAL ACTIVITY IN HIGH ALTITUDE LAKE SEDIMENTS (LAKE SON KUL, CENTRAL ASIA): A NOVEL APPROACH OF SEDIMENTARY FACIES ANALYSIS

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The fabric of sedimentary rocks in lacustrine archives usually contains long and continuous proxy records of biological, chemical and physical parameters that can be used to study past environmental and climatic variability. Here we propose a new approach of sedimentary facies analysis based on a coupled geomicrobiological and sedimentological study using high-resolution microscopical techniques (petrographic microscopy, scanning electron microscopy, transmission electron microscopy and laser scanning confocal microscopy) in combination with mineralogical (X-Ray) analyses. We test the applicability of this approach on sediments from Lake Son Kul, a high alpine lake in central Tien Shan (Kyrgyzstan, Central Asia), which covers the last 8000 years of the Holocene. This interdisciplinary study sheds a new light on the mineral fabric and microbial communities observed down to the nanoscale in lake sediments. The characterization of organo-mineral interactions allows unravelling the origin of four carbonate minerals (e.g. aragonite, dolomite, Mg-calcite, calcite) as primary or diagenetic phases in lake Son Kul. Aragonite was mainly of primary origin and is driven by biological activity in the epilimnion, whereas diagenetic minerals such as Mg-calcite, calcite, dolomite and pyrite were triggered by bacterial sulphate-reduction and possibly by methanotrophic archaea. Low lake levels are inferred between ca. 7000 and 5000 cal. BP, as indicated by the presence of interspersed aragonite deposits and microbial mat structures, in which anaerobic oxidation of methane played an important role and mediated the formation of a new morphotype of aragonite (i.e., spherulite-like precursor). Such microbial mat structures enhanced the preservation of viral relics, which have not been reported in Holocene lacustrine sediments yet. Hence this study advocates that microbe-mineral interactions screened down to the nanoscale (e.g., virus-like particles) can be used successfully for a comprehensive description of the fabric of laminated lake sediments. In this sense, they complement traditional facies sedimentology tools and offer valuable new insights to (i) study microbial and viral biosignatures in Quaternary sediments and (ii) improve palaeoenvironmental reconstructions.

THE MURRAY FORMATION OF LOWER MOUNT SHARP, GALE CRATER, MARS: A RECORD OF AN ANCIENT EVOLVING LACUSTRINE SYSTEM EXPLORED BY THE MSL CURIOSITY ROVER

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Since the Mars Science Laboratory Curiosity rover arrived in northern Gale crater in August 2012, the Curiosity team has addressed questions of early Mars habitability through the exploration of a diverse sequence of sedimentary rocks interpreted to preserve records of fluvial, fluvio-deltaic, lacustrine, and eolian environments. In September 2014 (Sol 753), Curiosity arrived at its main exploration target-the lowermost exposed strata of the 5 km-high mountain in the center of Gale, Aeolis Mons (informally, Mount Sharp)-and began its traverse upward through the 250 m-thick basal unit, the Murray formation.

At an outcrop named Pahrump Hills, the team characterized a 14 m-thick reference section for the lower Murray formation composed predominantly of reddish-gray mudstone exhibiting abrupt, angular truncation of low-angle inclined planar laminations. Distinct lenses of climbing ripple and dune crosslaminated mafic sandstone are interbedded within the mudstone. We interpret this to be a stacked sequence formed by bottom-hugging currents in a lacustrine setting interbedded with subaqueous channels representing more proximal deposition. Geochemical and mineralogical variations observed within the lower Murray formation reflect changes in provenance, authigenesis, and diagenesis. The transition from hematite-and phyllosilicate-bearing laminated mudstone to intervals containing magnetite and silica may record primary mineral precipitation that varied as a function of lake depth. Later diagenesis may have acted to promote further oxidation and saline mineral precipitation within the lower Murray formation.

By Sol 1350, the Curiosity rover began a dedicated southward ascent of the lower slopes of Mount Sharp. Between Sols 1350-1700, the Curiosity rover traversed a ~175 m-thick continuous interval of the middle Murray formation defined at its base by a ~25 m-thick interval of cross-bedded siltstone to very fine-grained sandstone characterized by decimeter-to meter-scale trough cross-bedding and decameter-scale concave up structures. Cross-stratification within this interval is consistent with bedload sediment transport in a subaqueous or eolian depositional setting. This interval is overlain by a heterolithic mudstonesandstone facies assemblage that includes broken and tilted blocks of: (1) reddish-purple planar thin laminated mudstone, (2) wavy, potentially centimeter-scale ripple cross-laminated mudstones and very fine-to fine-grained sandstones, (3) decimeter-scale cross-stratified sandstones, and (4) apparently massive, concretion-rich intervals. An increased concentration of diagenetic textures including concretions, variably oriented calcium sulfate veins, and calcium sulfate cements is observed throughout the middle Murray formation.

The presence of thin laminated mudstones throughout this interval is suggestive of a return to deposition by suspension settling in a lacustrine setting, though the presence of polygonal raised ridges inter-preted as desiccation cracks interbedded with shallower water bedload facies suggests that oscillating lake levels might have led to intermittent subaerial exposure. An increase in the proportion of coarser-grained sandy facies up-section through this interval may signal an overall shallowing of the lake(s) that once filled Gale crater. The geochemistry and mineralogy of the middle Murray, characterized by a hematite-phyllosilicate-gypsum association, may also be consistent with increased oxidation and evaporation in a shallowing lake setting.

MAGMATIC PULSE DRIVEN BY SEA-LEVEL CHANGES ASSOCIATED WITH THE MESSINIAN SALINITY CRISIS

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For more than four decades, large controversies about the causes, effects and timing of the Mediterranean Messinian Salinity Crisis (MSC) have evolved in the light of a continuously growing body of evidences. The igneous response to such extreme event, however, has remained largely unexplored despite known relationships between surface load variations and the production of magma. Here, we compile published geochemical and isotopic data and recognize a two-fold increase of volcanic eruptions from pan-Mediterranean magmatic provinces coinciding with the proposed "shallow-water phase" of the MSC between ~5.70-5.33 Ma. Estimates of surface load variations due to the desiccation event corrected for water density change and deposition of salt deposits suggest a net mean lithospheric unloading of up to ~15 MPa during the shallow-water phase of the MSC. Because the timescale of interest is too short for changes of the Mediterranean tectonics to significantly affect the bulk of the magma production, we propose that such net surface unloading enhanced the mantle decompression melting and dike formation, in turn causing the observed increase of volcanic events. If correct, the Mediterranean magmatic record provides an independent validation of the "shallow-water" model for the formation of salt deposits and testifies the high sensitivity of the melting of the Earth's interior to the surface forcing.

NATURAL VARIABILITY IN DETERMINISTIC PROCESS-BASED MODELLING: QUANTIFYING THE AUTOGENIC BEHAVIOUR OF DELTA MODELS

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Over the past years, there has been an increase in the number of studies that apply processbased models to simulate delta evolution. Process-based models, like e.g. Delft3D, are based on first principles. The underlying assumption of process-based models is that applying these principles (by using a numerical model) will increase our detailed understanding of complex multi-scale deltaic sedimentation patterns. Process-based models simulate small-scale bed level changes in great detail that, over time, result in the formation and progradation of an entire deltaic sediment body. The simulated hydrodynamics and sediment transport (erosion, bypass and sedimentation) commonly look realistic. The simulated delta shows many recognisable morphologic processes and features (avulsions, bifurcations, channel abandonment, channel migration, clinoforms, mouth bars, floodplains, etc.), which can be classified into sedimentary facies such as delta plain, mouth bar, channel, delta front and prodelta.

To simulate an evolving delta, you must define many boundary conditions, including river discharge, grain size and sediment concentrations, tidal and wave input parameters, and an initial bathymetry. In theory, models with identical boundary conditions will result in identical model output. However, minute (1 cm) changes in the initial bathymetry, which are small enough not to affect the driving hydrodynamics, result in initial minute morphological differences which then propagate over time as the delta further evolves. The resulting deltas are therefore different, yet show overall similar characteristics.

To quantify their similarities, we determined four morphological properties (delta plain area, delta progradation length, number of channels and channel dynamics) and quantified them over simulated time. The results show that the absolute range in variability of the selected morphological properties is stable over time. This range in variability can be referred to as the models autogenic variability. This finding has two implications: 1. The delta drivers (hydrodynamics and sediment transport) are robust and boundary condition variation propagates as ‘natural variability’ in the system which appears to be reach state of dynamic equilibrium, and 2. Process-based models cannot be conditioned to field data because reconstructed paleobathymetry is not detailed enough to resolve such minute variability.

Process-based model outcomes are typically treated as deterministic models. Our results however show that it is much better to treat process-based model outcomes stochastically, using the range of outcomes rather than one specific number.

DIAGENESIS ON THE EDGECLAY MINERAL COATS AND QUARTZ OVERGROWTH

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As the exploration of hydrocarbons moves into more complex and deeper basinal settings the need to understand the effect of high pressure and high temperatures (HPHT) on diagenetic processes, reservoir quality, and rock properties becomes even more important. Understanding the role played by clay mineral grain coatings in inhibiting quartz cementation in HPHT geological settings is of immense importance. This study utilises the examples from complex fluvial channel sandstones of the HPHT sandstone reservoirs of the Triassic Skagerrak Formation in the Central Graben, North Sea. Despite complex depositional setting, diagenetic history, high overpressures (> 40 MPa) and high temperatures (up to 185 °C) encountered, hydrocarbons are currently being produced from the HPHT reservoir sandstones of the Skagerrak Formation. To identify the role played by clay-grain coatings in maintaining exceptional reservoir quality in the HPHT reservoir sandstones to depth, a multidisciplinary approach involving petrographic analysis (optical, SEM, SEM-EDS, CL, fluid inclusions), as well as burial history, temperature and pressure modelling has been adopted across the Skagerrak Formation of the Central Graben, North Sea. Furthermore, results from hydrothermal reactor experiments highlight the morphological evolution and interaction of authigenic clay-grain coatings and quartz cement overgrowths under high pressures and high temperatures. The regional comparison of the clay-grain coatings, the type and quantity of quartz cement overgrowth, as well as the implications of temperature and pore fluid pressure in combination with the hydrothermal reactor experiments demonstrate the importance of understanding the pressure and temperature evolution for the diagenetic phases in the Skagerrak Formation sandstones. The results indicate that grain coats tend to develop thinner under lowerpressure conditions (< 15 MPa) with higher amounts of macro-quartz cement. Conversely, higher-pressure conditions (> 15 MPa) tend to develop thicker and more regular clay-grain coats resulting in effective inhabitation of macro-quartz overgrowths even at high temperatures (130-170°C). Hydrothermal reactor experiments provide experimental evidence that increased chlorite grain coating growth rates correspond with increased pore fluid pressures. However, under higher-pressure (> 70 MPa) and high-temperature (> 115 °C) conditions quartz tend to nucleate and precipitate as micro-quartz in-between and beneath the chlorite grain coatings. This study has demonstrated for the first time the effects of pore fluid pressure on the development of authigenic clay-grain coatings and quartz cement overgrowths and highlights the significance of understanding the development and the evolution of pore fluid pressures during burial.

UNDER PRESSURE – EFFECTS OF PORE FLUID PRESSURE ON RESERVOIR QUALITY

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As hydrocarbon exploration moves to more complex and deeper basinal settings the need to understand the effect of high temperatures and high pressures on reservoir quality and rock properties become even more important. The complex fluvial sandstones of the Triassic Skagerrak Formation are the host reservoir for a number of high-pressure, high-temperature (HPHT) fields in the Central Graben, North Sea. Despite broadly similar burial and diagenetic histories the fine to medium-grained sub-arkosic to arkosic fluvial sandstones show major variations in reservoir quality and preserved porosity. Reservoir quality varies from excellent with anomalously high porosities of up to 35% at burial depth of > 3500 m to non-economic with porosities < 10% at burial depth of 4300 m. This study combined core analysis, detailed petrographic analyses (optical, SEM, SEM-EDS, CL, fluid inclusions), as well as burial history, temperature and pressure modelling to assess the impact of differing vertical effective stresses (VES) and high pore fluid pressures (up to 80 MPa) on reservoir quality. It has been recognized that the fluvial channel sandstones of the Skagerrak Formation in the UK sector have experienced significantly less mechanical compaction than their equivalents in the Norwegian sector. This difference is key to reservoir quality, even though the presence of chlorite grain coatings inhibited macroquartz cement. It is the cumulative effect of varying amounts of overpressure and its effect on the VES history that is key to determining the reservoir quality of these channelised sandstone units.

FLUID MIGRATION PATHS THROUGH SUPERIMPOSED CENOZOIC TO MESOZOIC FAULTS AND FAULT SYSTEMS – A CASE STUDY IN THE SW-GERMAN NORTH SEA

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In an epicontinental basin, sedimentary and structural elements in the Mesozoic to Cenozoic deposits, e.g. tunnel valleys, polygonal fault systems, faults related to salt structures, are common features. In regions where these structures superimpose, they may form network-like fluid pathways connecting the top Zechstein and the seafloor. Moreover, a hypothetical genetic dependency of such a superposition of structural elements, e.g. between tunnel valleys and salt diapirs as well as between salt diapirs and polygonal faults has been discussed in literature. However, within the German North Sea sector a comprehensive (mapping) study dealing with these linked topics is missing so far.

This study, which is embedded in the TUNB-project (subsurface potentials for storage & economic use in the North German Basin) of the Federal Institute for Geosciences and Natural Resources, aims to characterize a possible (genetically) interaction and/or superposition of glaciogenic erosional structures with underlying structural elements in the SW-German North Sea, such as crest fault systems, polygonal faults and sediment bodies of a delta system. We will identify regions of increased connected fault/structure system in the overburden top down of SW-German North Sea sector, and aim to evaluate the possibility of fluid pathways formed by interconnection of such structural features.

To achieve this, in a first step all structural elements are mapped based on a comprehensive 2D-seismic data set and, subsequently in a second step, surface modeling is accomplished. Based on this, following attribute maps are compiled: i) regions, where tunnel valleys intermesh with crestal faults, ii) regions, where tunnel valleys are in contact to faults/step faults within Cenozoic sedimentary successions, iii) regions, where tunnel valleys are in contact to faults/step faults within Cenozoic to Mesozoic sedimentary successions, iv) regions, where polygonal faults are penetrated by faults affecting the Cenozoic and v) regions, where polygonal faults are penetrated by faults affecting the Cenozoic to Mesozoic.

The results of the present study may contribute to a future, high detailed structural 3D model and to a qualitative evaluation of the influence on barrier properties.

REDUCED SEDIMENT SUPPLY IN A FAST ERODING LANDSCAPE? A MULTI-PROXY SEDIMENT BUDGET OF THE UPPER RHÔNE BASIN, CENTRAL ALPS

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Mountainous regions with their high topography, high relief and high erosion rates are amongst the most important clastic sediment factories on our planet. The amount of sediment produced in such systems is regulating the sediment budgets of many important fluvial systems on our planet. Especially in the light of rapid climate change and increasing human impact onto the landscapes, it is crucial to understand the dynamics and feedback mechanisms of sediment production and supply in these sensitive environments.

We here report on the sediment dynamics of the upper Rhône basin, located in the heart of the European Alps in southwestern Switzerland. The upper Rhône basin is one of the largest Alpine in-tramontane basins and is characterized by high orographic rainfalls, high relief and presumably some of the highest erosion rates measured in the Alps today.

We present two datasets: The first one comprises compositional fingerprints (based on framework petrography, heavy mineral analysis and bulk geochemistry) of the major sediment sources present in the basin. By sampling and fingerprinting fluvial sediment at the outlet of the Rhône basin and performing compositional mixing modelling, the relative contributions of the sediment sources to the fluvial sediment are calculated. This dataset provides a modern snapshot of sediment fluxes within the basin. The second dataset comprises absolute rates of denudation for selected tributary basins based on the concentrations of the terrestrial cosmogenic nuclide ^{10}Be measured in quartz. These spatially averaged denudation rates, which range between 0.2-2.7 mm/year, provide insight into sediment production averaging over longer time spans (ca. 200-3000 years). Results show that granitic and carbonate bedrock located in the North and the East of the basin are generating most of the sediment found at the outlet of the basin, whilst sediment derived from metamorphic bedrock in the South of the basin is relatively underrepresented. However, the denudation rates are comparable between the different lithologies, or even slightly higher for the metamorphic bedrock.

We interpret this discrepancy between sediment production (denudation) and sediment supply as an expression of spatially variable sediment storage. The largest tributary catchments within the Rhône watershed are underlain by metamorphic bedrock with high denudation rates. Basic hydrological relationships would suggest that these large catchments should supply more water and, as a consequence, more sediment than smaller catchments. However, the size of these catchments provides significant accommodation space and increased transport duration and distances, leading to temporary sediment storage. In addition, anthropogenic water abstraction in hydropower systems in these large basins may contribute to decreased water supply and sediment transport capacity and may prevent the remobilization of sediment trapped in temporal storage systems.

INTERACTION OF TECTONIC MOVEMENT AND SEA LEVEL FLUCTUATION IN A LATE QUATERNARY SEA-CONNECTED INLAND COLLAPSE BASIN, TAIPEI BASIN, NORTH TAIWAN

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In order to decode the influence of tectonic movement and eustatic sea level fluctuation on stratigraphic architecture in a sea-connected, inland active collapse basin, the sedimentary environmental change after 50 ka and the stratigraphic architecture of the Taipei Basin have been reconstructed by facies analysis of 36 borehole cores and age-depth models from 177 age datings. Comparing dating sampled depth, eustatic sea level and paleo-water depth, tectonic movement can be deduced. Tectonic subsidence events triggered by plate subduction reversal affected the near-boundary-fault area of the Taipei Basin. During the last glacial lowstand, accommodation space provided by tectonic subsidence countervailed the effect of eustatic sea level fall so the base level rose after 35 ka. Although tectonic uplift took place between 15 and 10 ka, the accommodation space was increased due to the fast rising sea level. In the far-fault area, a sedimentary hiatus between 20 and 10 ka is due to the lack of tectonic subsidence before 15 ka, and tectonic uplift after 15 ka. A very fast tectonic subsidence brought the inland Taipei Basin to an estuary ca. 10 ka, which is several thousand years earlier than other Holocene estuaries caused by rising sea level, and the estuary expanded into the basin interior quickly. After ca. 8 ka, the estuary was gradually backfilled, however, in the far-fault area, tectonic uplift showing in 7.8~6.8 ka caused another sedimentary hiatus. The hiatuses in the far-fault area and the relatively continuous deposition in the near-fault area made the studied successions wedge-shaped, which is a specific feature of rifted half-graben basins. This study proposed that in an active collapse basin, the wedge successions were not only affected by tectonic subsidence but also tectonic uplift, which might be driven by regional buoyancy and local change of fault geometry.

ORGANIC INDICES TO CHARACTERIZE THE MATURITY OF SOME SHALE OIL RESOURCE SYSTEMS: A CASE STUDY

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A shale oil resource system is an hydrocarbon system that cannot be exploited by means of conventional production technologies (vertical wells) and may require of advanced techniques for hydrocarbon extraction. This kind of systems are therefore included in the range of unconventional petroleum systems.

In the multidisciplinary assessment of a shale oil resource system the first step involves a geologic characterization of the sedimentary basin and its formations. The conditions that such a system should accomplish are: i) a TOC content of ≥ 2 %; ii) type and nature of organic matter of high quality; iii) a thermal organic maturity inside the oil window (vitrinite reflectance: 0.7%1.0%); iv) a prospective depth range of 1,000 m to 5,000 m; v) a shale mineralogy; and vi) other conditions such as overpressure, geologic complexity, volumetric data, oil saturation to determine the possibility of commercial exploitation of oil, etc.

Among the indices describing the organic maturity the most robust and reliable parameter is the vitrinite reflectance. However, this parameter is subject to some serious limitations. The main problem in the case of some organic-rich rocks containing kerogen Type II is the scarce to null content in vitrinite particles. In such cases it is necessary to find other indices that may approach to the maturity degree reached by the organic matter.

In the field of the organic petrology there are a series of maturity indices applied with relative success to the study of the rock thermal maturity. However, all of them have similar problems and limitations such as: short range of application, low reliability, presence/absence of components that are used as maturity indices and the most important: none of these indices are of universal application.

This work discusses the applicability of some organic indices to determine the maturity of a shale oil resource system, the La Luna Formation located in the Cretaceous sedimentary sequence from the Middle Magdalena Valley (MMV) basin in Colombia. This formation is characterized by it kerogen type II content of very high quality but also by its vitrinite paucity. The final assessment of its organic maturity by using some petrographic (solid bitumen reflectance, organic fluorescence) and geochemical (Tmax) indices in combination, together with the organic-rock composition allowed the identification of sedimentary levels with oil generated in situ, levels with migrated oil and sedimentary levels with mixtures of oil (migrated from closer rocks and oil generated in situ).

PALEOGEOGRAPHIC CONTROLS ON ORGANIC CARBON BURIAL DURING THE TOARCIAN OCEANIC ANOXIC EVENT

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The Toarcian Oceanic Anoxic Event (T-OAE; Early Jurassic) was a time of marked environ-mental perturbations, which led to the widespread deposition of organic-rich strata known as 'black shales'. Although organic-rich deposits of this age occur in many individual epicontinental basins located at nearly all paleolatitudes, very high total organic carbon contents (> 10 wt. %) are generally restricted to NW European basins, suggesting that paleogeography exerted a strong control on carbon burial during the T-OAE. Several models have been developed to account for these contrasts, which include the input of nutrient-rich and less saline waters from the Arctic, oceanographic basin restriction and local nutrient delivery. In this study, these various models are tested using a compilation of chemostratigraphic, biostratigraphic, cyclostratigraphic and geochemical data from several basins where the T-OAE has been documented. Surprisingly, organic carbon mass accumulation rates appear to have been relatively low (0.5 to 1.5 gC. m^{-2}. yr^{-1}) in the majority of organic-rich NW European basins, where the limited thickness of T-OAE deposits (< 5 m) suggests that organic enrichment in this area was enhanced by the reduced input of argillaceous and carbonate material. By contrast, highest organic burial rates (> 2 gC. m^{-2}. yr^{-1}) are reconstructed for some sites of central Europe (Slovakia, Hungary, and Austria), where the successions are more expanded (> 15 m) but record much lower TOC contents (2 to 4 wt.%). Apart from these European sites, organic burial rates were also elevated in the equatorial Tethys, where the T-OAE in recently published data from Tibet shows both elevated TOC contents and relatively expanded records. Several basins of high and low paleolatitudes, independently of sedimentation rates, record low organic carbon burial rates (< 0.5 gC. m^{-2}. yr^{-1}) suggestive of relatively well-oxygenated conditions. These comparisons indicate that the high TOC content in T-OAE strata cannot be simply used as a proxy for the degree of oxygenation and export productivity, and challenges models implying the input of Arctic waters and local oceanographic restriction as the main causes of black shale deposition in NW Europe. It is here suggested that models proposed to explain the distribution of 'black shales' during the T-OAE should better integrate the paleogeographic variability of productivity, oxygenation, accomodation space and detrital sediment input.

POLLEN RECORDS AND CLIMATOSTRATIGRAPHY: A POWERFUL TOOL FOR SHORT-TO LONG-DISTANCE CORRELATIONS OF CENOZOIC DEPOSITS

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Palynology contributes for long to stratigraphy, based on presence-absence of plant taxa (i.e., families, genera or species), a method severely thwarted by longitudinal and mainly latitudinal-altitudinal distribution of plants.

Following pollen analysis applied to late Quaternary deposits, so successful not only for climate reconstructions but also for short-to long-distance stratigraphic correlations, we developed a similar approach for the whole Cenozoic thanks to actual botanical identification of pollen grains based on their complete and rigorous morphological examination. Usually, identifications are provided at the genus level considering that most of the modern genera existed since the early Paleocene.

The age of each studied exposed or drilled section is first determined using worldwide biostratigraphic markers (planktonic foraminifers, calcareous nannofossils, dinoflagellate cysts for marine sediments; micromammals for lacustrine deposits) and paleomagnetism. Then, pollen countings allow establishing diagrams in which pollen percentages and/or ratios express the climate evolution and match with reference oxygen isotopic curves. In such a frame, it is possible to identify similar and parallel climatic changes that may be reliably correlated. Illustrative examples are shown from the European and Mediterranean Pliocene and Miocene and from Paleocene and Eocene from the Arctic Ocean, i.e. from the icehouse and greenhouse worlds, respectively.

Finally, this Russian doll-like process, with biostratigraphic datation followed by climatostratigraphic correlations, may result in the astronomical deciphering of the most favourable sections. Such stratigraphic studies were supported by Total since 1970.

QUATERNARY TECTONO-SEDIMENTARY EVOLUTION OF A MAJOR SEISMOGENIC ZONE: SEDIMENTOLOGICAL AND GEOCHRONOLOGICAL INVESTIGATION OF THE DOBRÁ VODA DEPRESSION (WESTERN CARPATHIANS, SLOVAKIA)

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The Dobrá Voda depression represents a major seismogenic zone on a transition between Vienna and Danube basins in the Eastern AlpineWestern Carpathian junction. The only 5 km wide basin is bounded by elevated horsts of Mesozoic carbonates and early to middle Miocene clastics. Sedimentological investigations and dating methods were applied to Quaternary sedimentary fill of the depression to determine maximum potential slip rates on the delimiting faults. Geometry of the sedimentary bodies was investigated through well data and resistivity tomography surveys, which were both archival and newly performed. Analysis of facies and sampling for radionuclide dating was carried out in five newly drilled boreholes and two trenches. We applied exposure dating with ^{10}Be, ^{26}Al and ^{36}Cl depth profiles, ^{26}Al/^{10}Be burial dating and radiocarbon dating. The Quaternary sedimentary record of the depression consists mostly of alluvial deposits, with presence of colluvial strata close to its margins and locally thin loess cover. River deposits attain thickness of 10 to 30 m. Gained results allowed to determine the following evolution phases of the depression:

1) Early Pleistocene: Low dynamic alluvial deposition in a low differentiated topography. Minor streams accumulated sequence with dominance of floodplain strata in conditions of low sediment supply/accommodation ratio. The dominantly fine-grained succession is in position of a terrace 40 m above recent streams.

2) Middle Pleistocene: Relative uplift of the area caused topographic differentiation associated with establishing of the horst-graben framework. Incision of streams into the Early Pleistocene succession led to forming of a river network comparable to the present. In areas of recent floodplains were accumulated successions of mostly gravelly-sandy composition in conditions of high sediment supply/accommodation ratio.

3) Late Pleistocene: Termination of the topographic differentiation connected with decrease of the tectonic activity of normal faults, what was confirmed by exposure dating of a fault scarp. Deposition appeared mostly in the eastern part of the depression, indicating asymmetrical distribution of the fault activity.

4) Holocene: Low dynamic deposition of the overbank fines on most of the floodplains. A pond environment with deposition of more than 2 m thick peat appeared in the central part of the depression. Documented slip rates of normal faults reach low values in the order of 50 mm/ka according to presented information. Paleoseismic investigation indicates a decrease of tectonic activity from the Middle Pleistocene, while last significant tectonic movements occurred within the last glacial period. Normal fault movements reach values below the sensitivity limit of used methods during the Holocene to recent times.

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POROSITY AND DIAGENETIC HETEROGENEITY OF TURBIDITE SANDBODY IN SHAHEJIE FORMATION, BOHAI BAY BASIN, CHINA AND IMPLICATIONS

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The entity of diagenesis which refers to the physical and chemical processes that affected sedimentary materials after deposition and weathering was always an outstanding issue. We try to figure out its complicated process by studying them as a whole diagenetic system, which are composed of the deeply buried (3100~3300 m) turbidite sandbodies and the surrounded shales. The turbidite sandbodies of five diverse distribution patterns were lying at Shahejie Formation in the rift basin of eastern China. 141 core samples, including sandstones and shales, were acquired within sandbody and near the sand/shale contact (SSC) by densely sampling.

Based on analysis of thin section, X-Ray Diffraction, Scanning Electron Microscopy and Cathodoluminescence Micrography, those samples' diagenesis and its differences between the exterior and the interior of turbidite sandbody were analyzed.

We found that the porosity of turbidite sandstones showed many variations between the interior of the sandstones and the SSC: (1) high porosity (20%) only in the interior; (2) high porosity (6%) only near the SSC; (3) low porosity (1%) through all the sandstones. The reason for low porosity was the present of carbonate cements. The quantity and sorts of carbonate cements formed during increasing burial depth is much more in the external (> 15%) than in the interior of turbidite sandbody (< 3%). The most reasonable explanation was shale as the source for a portion of the diagenetic cements near the SSC in the whole diagenetic system. The thin sections show that between 65°C and 140°C, sandstones and shales undergo massive chemical and textural reorganization. In this temperature interval with deep burial of sandstones and late-stage illitization of shales, unequal amounts of reactive components in the SSC created episodic chemical gradients when the local rate of surface reaction of the reactive component exceeded the local rate of transport, so the diffusive transport process was formed. More solutes were generated per unit time in the intervals with greater amounts of reactive component. Solute transports between adjacent sandstones and shale within pore fluids driven by the chemical gradients. Near the SSC, a cement band was formed rapidly on a geological scale and sufficient to take up over distances of 1 to 3 meters in lenticular sandbody. Sufficient burial depth could afford the temperature threshold to the formation of chemical gradient. The scale of lenticular sandbody and shales would influence the cement extent and cement distribution. Sorts and quantity of composition in both sand and shale would dominate episodic diffusion gradients and the direction and velocity of the transfer mass. The whole diagenesis evolution result proved that shales play an important role in the process and must be considered in to sandstone diagenesis.

TYPES AND DISTRIBUTIONS OF CLAYS AND THE EFFECT ON QUALITY IN LOW-PERMEABILITY CLASTIC RESERVOIRS

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Clays cause significant effect on low-permeability clastic reservoirs. Based on grain size analysis, X-ray, casting thin section, scanning electron microscopy and high pressure mercury injection of low-permeability clastic reservoirs in underwater distributary channels in braided river delta front, we analyzed the basic characteristics of clay minerals, and focused on their distributions, formation mechanisms and impacts on different lithologic reservoirs.

Clays are mainly composed of chlorite, illite, and illite-smectite mixed layer with a tiny amount of kaolinite. Chlorite presents as pore-linking and pore-filling. Illite is fibrous and irregular flaky. Illite-smectite mixed layer is mainly honeycomb and irregular flaky. Kaolinite fills pore as book structure. The total amount of clay minerals and the distributions closely relate to the reservoir lithology. The relative contents of chlorite reduce with the decrease of sandstone grain size, meanwhile the total clays and the relative contents of illite and illite-smectite mixed layer increase. Conglomerate has high total clays and relative contents of illite and illite-smectite mixed layer, and low relative contents of chlorite. Clays consist of matrix and diagenetic clay. Matrix clays in fine sediments increase with the decrease of sandstone grain size. The rapid hybrid deposition of poor sorting sediments results in high matrix clays in conglomerate.

Diagenetic pore-linking chlorite results of the recrystallization of early clay coating, formed by flocculation and adsorption of suspended clay in synsedimentary stage, or crystallization from pore fluids in strong hydrodynamic condition. Chlorite cement intensity (the ratio of absolute content of chlorite and specific surface area of rock) weakens with the decrease of sandstone grain size. Conglomerate has weak chlorite cement intensity. Pore-linking chlorite occupies the nucleation basal of siliceous cement and forms the stable irreducible water film, which inhibits element and energy exchange between pore fluid and particle surface. This restricts early siliceous cement, which benefits the preservation of primary pores. Authigenic illite and illite-smectite mixed layer are mainly relevant to the dissolution of feldspars and lithic fragments. The content of quartz reduces with the decrease of sandstone grain size, which weakens resistance to compaction and preservation of primary pores. The compaction of conglomerate is intense due to the poor sorting and high matrix. Abundant primary pores of conglomeratic sandstone, coarse sandstone and medium sandstone contribute to the dissolution in these reservoirs. Low permeability reservoirs are under the closed diagenetic environment, which causes the dissolution matters are difficult to take a long-distance migration. Moreover, the dissolution matters of the reservoirs with richer pores can transport to adjacent upper fine sandstone and lower conglomerate and cement there, which results in the development of clays cement in these reservoirs. Illite and illite-smectite mixed layer diminish pore throat radius, divide pore throat, enhance tortuosity and destroy connectivity.

FAN DELTA SEDIMENTARY CHARACTERISTICS IN EOCENE OF NANPU DEPRESSION, BOHAI BAY BASIN, CHINA

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The sedimentary characteristics in Eocene siliciclastiscs of the Nanpu Depression, northern part of Bohai bay, China, is discussed by an analysis of rock constituents, rock texture, sedimentary structures, lithofacies and logging information.

The sandstones have a low content of quartz and feldspar and a high content of rock debris and are mainly lithic arkose and feldapatic litharenite. In general, the content of stable components is less and sediment maturity is lower than in other deposits of the Nanpu depression. Ten lithofacies were distinguished: massive conglomerate (Gm), massive or weakly to poor stratified conglomerate (Gms), stratified gravely sandstone (Gt), medium to very coarse-grained massive sandstone (Sm), coarse-grained trough cross-bedded sandstone (St), medium-to coarse-grained planar cross-bedded sandstone (Sp), ripple cross-laminated sandstone (Sr), very fine-to medium-grained sandstone with plane bedding (Sh), parallel laminated siltstone and claystone (Fl) and massive mudstone (Fm). Various lithofacies combinations represent different subfacies of fan delta sedimentation. Regressive fan deltas are represented by coarsening-upward sequences, which can be divided into fan delta plain, fan delta front and profan delta subfacies. The fan delta plain is mainly composed of sandy conglomerate, very coarse to-massive sand channel fills, with some faint trough cross bedding. The fan delta front deposits consist of weakly stratified conglomerates, medium-to coarsegrained trough and planar cross bedded sandstones with gray-green mudstones. The profan delta developed gray green, dark grey mudstones. Transgressive fan deltas are characterized by a fining-upward sequence. They can be divided into proximal fan, middle fan and distal fan subfacies. Proximal fans are formed by intermittent water flow and braided channel sedimentation with poorly sorted and stratified conglomerates, showing imbricated clasts and trough cross bedding at the bottom. The lower boundary is usually erosional and sharp with the underlying mudstone. Middle fan units form the main part of the fan delta, with well-developed braided channel deposits mainly developed in medium-to very coarse-grained sandstones and rarely gravelly sandstones with small trough and planar cross bedding and a sharp erosional base. The interchannel bay is represented by gray green to dark grey massive or weakly laminated muds with low-density bioturbation and thin sandstones with small-scale ripple bedding and deformational structures. Distal fans are formed in semi-deep lacustrine environments and consist of mainly green or dark grey muds with some bioturbation.

Fan delta depositional systems developed good reservoirs, and are becoming one of the main oil and gas exploration targets. Therefore, the study of the fan delta sedimentary characteristics is of great value.

EARLY MIOCENE SAPROPELS IN THE MALDIVES CARBONATE ARCHIPELAGO

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During drilling of the Maldives archipelago by IODP 359, thick sequences (~100m) of interbedded sapropels and pelagic carbonates were encountered in sediments of late Oligocene and early Mioceneage at Sites 359-U1466 and 359-U1468. This occurrence was unusual in that it was located > 1000 meters above the ocean floor within an inter-atoll basin and not linked to any known global oceanic events. Concentrations of organic material reached as high as 35 % in the darker layers, while the interbedded oceanic carbonates had concentrations of less than 0.1%. Trace elements characteristic of anoxic bottom waters, such as Mo, V, Cr, Cd, U, and Pb, correlate positively with variations in the concentration of organic carbon. Nitrogen isotopic data show no evidence that the intervals of high organic material are related to enhanced productivity driven by upwelling. Instead, organic carbon content variations are associated with bottom water oxygenation with intervals of anoxia in the bottom water, leading to enhanced organic carbon preservation. The sapropels display an alternation of laminated and poorly bioturbated dark intervals with highly to completely bioturbated white intervals. Sediments of the dark intervals have abundant particulate inorganic matter with planktonic foraminifers, fish debris and nannofossils, indicating marine conditions. The dark layers are finely laminated and locally show scattered discrete burrows of *Thalassinoides*, *Phycosiphon, Palaeophycus*, and *Planolites*. The dark intervals range in thickness from 1 to 25 cm and are intercalated with white wackestone intervals of 5 to 300 cm thick. The sediment in the white intervals also has planktonic foraminifers and nannofossils, but fish debris are rare to barren. These intervals are highly bioturbated and discrete burrows are hard to identify. Identifiable ichnogenera in the white intervals include *Zoophycos* and *Chondrites*. The organic content and number of darker layers increases towards the bottom portion of the section. It is proposed that the sapropels were initiated following a sea level rise in the late-Oligocene. Subsequent sea level fluctuations (lowering of sea level) restricted exchange between the open Indian Ocean and the Maldivian Inner Sea causing the bottom waters of a basin to become anoxic periodically. The unique architecture of the Maldivian platform at the end of the Oligocene with an elevated rim surrounding the platform interior combined with the high global sea level set the stage for orbitally-driven sea level changes periodically restricting the ventilation of the Maldives Inner Sea producing cyclic deposition of sapropels. The phenomenon ended when the amplitude of sea level changes failed to produce basin anoxia.

UNRAVELLING 10 MA OF ENVIRONMENTAL AND CLIMATIC CHANGES IN AFRICA: THE LAKE CHAD DEEP DRILLING PROJECT (CHADRILL)

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At present, Lake Chad is a shallow freshwater lake located in the Sahel/Sahara region of central northern Africa. The lake is primarily fed by the Chari-Logone River, which drains a ~600,000 km^2 tropical watershed. Discharge is strongly controlled by the annual passage of the Inter-Tropical Convergence Zone (ITCZ) and monsoon circulation leading to a peak in rainfall during the summer. The large number of studies carried out on the Lake Chad Basin (LCB) has mostly been focused on relatively few exposed lacustrine outcrops and shallow cores.

CHADRILL is an ICDP proposal to recover the Mio-Pleistocene sediment succession of Lake Chad. This record will provide significant insights into the modulation of orbital-forced variations in the North African hydroclimate under different extreme environmental settings, such as high atmospheric CO_2 values and during times of neglected extent of high latitude ice-sheets. We propose that CHADRILL will increase our knowledge on the origin of the lake and the current surrounding desert as well as its possible relation with the Mediterranean Sea, to which it probably was in charge of supplying considerable freshwater during the Late Miocene. The LCB is also very rich in early hominid fossils (e.g., Australopithecus bahrelghazali and Sahelanthropus tchadensis) of Late Miocene age. Thus, retrieving a continuous sediment core from this basin will enhance our understanding about the climatic and environmental conditions that led to hominid migrations across North Africa. Consequently, the study of the subsurface biosphere contained in these sediments has the potential to shed light on early life on Earth and other planets.

Our preliminary drilling plan involves a multi-site approach with deep holes in the southern basin at easily accessible and protected sites to recover Miocene-Early Pleistocene deposits. Known outcrops encompassing deposits of maximum lake extent will be targeted by shallow drilling to the north of the basin.

Acknowledgments: We advocate that the CHADRILL project will provide a valuable base of understanding for African climate reconstructions since the Miocene.

GRAIN SIZE OF TSUNAMI DEPOSITSA CRITICAL REVIEW

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The last three decades have faced a rapid increase in a number of studies on tsunami deposits. A single major reason is the need for correct identification and interpretation of tsunami and palaeotsunami deposits, to provide a better understanding of event frequency and magnitudes for tsunami hazard assessment purposes. Most of these studies included a common characteristic of tsunami depositsgrain size distribution. In fact, since the pioneering studies the grain size variability and trends (e.g. landward and upward fining) were among the key diagnostic features used for identification of tsunami deposits. However, although large number of studies employed grain size analyses only few of them focused on the processes affecting this characteristic. The goal of the present study is to review the state of art in application of grain size analysis in tsunami deposits studies, which is supplemented by new data from 2004 Indian Ocean tsunami deposits in Thailand, 2011 Tohoku-oki tsunami deposits and 2000 landslide-generated tsunami on Greenland. Among the major factors affecting the grain-size of tsunami deposits are: sediment sources, sedimentary processes during the tsunami and postdepositional alteration of the deposits. Among the major emerging discussion issues are formations of fining upward sequence and of mud caps. These two characteristics are often considered as typical for tsunami deposits and are assumed to form during the reduced water flow upon the time of flow direction reversal (runup vs backwash). The selected examples show that in many cases these characteristic may be formed during relatively fast water flow. For instance, the upward fining grain size may be formed due to differential settling limited sediment supply to the bedload traction, and the resulting deposits may reveal lamination. While the formation of mud caps, often composed of poorly sorted sediments, must take into account flocculation processes. The overall analysis reveals several pitfalls in common application of grain size analysis for tsunami deposits but also highlight large potential of this standard analysis in revealing details of the processes acting during a tsunami.

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CLIMATE DRIVEN VARIATIONS IN SOURCE TO SINK FLUXES OF SEDIMENT AND CARBON IN A HIGH ARCTIC FJORD (HORNSUND, SVALBARD)

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The Arctic areas, like Svalbard, are particularly sensitive to global climate changes as proved by modern monitoring data and the past records. One of the most spectacular changes is the rapid retreat of tidewater glaciers during the post-Little Ice Age period (after ~1900) observed in many subpolar fjords in Svalbard. Due to the retreat, new bays have been formed in the inner parts of the fjords. They serve as efficient sediment sinks characterised by high sediment accumulation rates. The climate-related changes in glacier dynamics, the bays topography, sediment storage, and a number of environmental factors affected also the sediment fluxes from source (basin glacier-covered catchment) to newly formed sinks. The sediments contain also carbon, thus the sediment fluxes and their variations may be considered also in terms of carbon fluxes and burial. The later is particularly important in context of recent understanding of fjords as hot spots of organic carbon burial in global scale.

The present study aims to present source to sink approach in unprecedented spatial and temporal resolution for Hornsund fjord (southern Spitsbergen) using several approaches: dense grid of high resolution ^{210}Pb and ^{137}Cs-dated sediment cores, bulk geochemical analyses, organic carbon age analyses (^{14}C), supplemented by bathymetric data and coastal zone mapping. Along with the relatively good historical documentation of glacier front positions and climate during the post-Little Ice Age period it allowed to quantify the sediment and carbon fluxes to the new bays in decadal scale.

The sediment dispersal pattern seems to be largely affected by glacier retreat rates, changing bay geometry and increase in influence of oceanographic conditions. The accumulation rate reaches several cm/year in proximal zones and rapidly drop to relatively stable rates of few mm/years. The high sediment accumulation rates along with relatively high organic carbon content (c. 2%) result in extremely high carbon burial rates (in order of several hundreds of gOC / m^2 / yr). It makes the studied bays an important carbon sink. However, most of the carbon comes from subglacial erosion of older sedimentary rocks, not from modern sequestration of atmospheric carbon.

The subpolar fjords undergoing the fast retreat of tidewater glaciers may be considered as systems of accelerated source to sink transfer. It is likely in contrast to conditions during colder Little Ice Age, when a lot of sediments could be temporary stored in glacial system. Due to the high rate of modern sediment transfer, the new deposits retain many characteristics of the source rocks.

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SEDIMENT FLOCCULATION IN FJORDS: TIDEWATER GLACIER BAY VS RIVER-DOMINATED BAY

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Fjords form a large part of the coastal zones and act as a transition between land and sea. They serve as sediment traps and affect for instance carbon cycle through efficient carbon burial. The dominant sedimentary process in most fjords is sedimentation from the brackish plume rich in suspended particulate matter that emerges from either glacier-fed river mouths or tidewater cliffs. Although this process is generally relatively well studied and flocculation process is acknowledged, little is known about the details of the flocculation process and its development in time. Here we present a detail study for two settings in subpolar fjordHornsund (southern Spitsbergen). The first setting is a bay in front of tidewater glacier Hansbreen. The bay is up to 90 m deep and is characterised by up to 10 m thick near-surface brackish water layer. The second setting is in a bay supplied by meltwater river Gåselva. The studied part of the bay is down to 30 m deep and the brackish water layer is confined to the uppermost 2 m. The study is based mainly on the in-situ LISST measurements of the suspended sediment concentration and grain size distribution of sediment particles. The measurements were taken in vertical profiles, in lines perpendicular to the freshwater inflow direction. The measurements were supplemented by CTD and water sampling. The obtained results show two contrasting scenarios. In case of bay dominated by tidewater glacier the relatively uniform flocs are in the upper brackish layer, however below it is present only aggregates larger by at least an order of magnitude. In case of riverdominated setting the flocs form rapidly upon reaching the fjord waters, they are larger but the water density contrast is strong enough to keep them in suspension. The water surface suspended sediment concentrations are usually much lower than the average concentration in the uppermost brackish layer.

The flocculation seems to play a key role in sediment deposition in subpolar fjords. However, although it causes that sediment generally are deposited close to the source, the flock sizes must reach certain size to pass the water density boundary between upper brackish water and deeper waters characterised by the full salinity. This process must be taken into account during modeling studies as well as in remote sensing studies of sediment suspension in fjords.

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GAMMA-RAY SPECTROMETRY IN ORGANIC-RICH SEDIMENTARY CARBONATE DEPOSITS: AN EXAMPLE FROM THE LOWER JURASSIC OF THE LUSITANIAN BASIN, PORTUGAL

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The Lower Jurassic carbonate successions cropping out in the onshore areas of the Lusitanian Basin (Portugal) include three well characterized organic-rich intervals: the Unit F of the Coimbra Formation, the Polvoeira Member of the Água de Madeiros Formation, and the Marly limestones with organic-rich facies member of the Vale das Fontes Formation. These units are dated from the Sinemurian–Pliensbachian and are regarded as potential hydrocarbon source rocks.

However, these source rock intervals have not yet been identified in the offshore areas, mostly due to the poor stratigraphic definition of the Lower Jurassic in the several wells drilled in the basin. The uncertainty regarding source rock documentation increases the risk associated with the assumed petroleum systems and hinders the exploration efforts along this portion of the Portuguese margin.

In order to recognize these organic-rich intervals in the offshore areas, highlight their lateral extension, and improve the overall stratigraphic definition of the Lower Jurassic in the Lusitanian Basin, the objective of this work is to compare several detailed Gamma-ray (GR) profiles from the onshore outcrops (i.e. Peniche, S. Pedro de Moel, Figueira da Foz, Montemor-o-Velho, Coimbra, and Rabaçal) with several offshore wells.

More than 1570 field measurements indicate that the highest GR values and U contents are consistently observed in the aforementioned organic-rich intervals, reaching up to 134 API and 8.7 ppm of U. Contrasting, the lowest API and U values we determined in dominantly calcareous units, ranging between 5-34 and 0.4-1.4 ppm, respectively.

Field GR log patterns show a good correlation with the offshore wireline GR logs, allowing, and for the first time, the recognition of these organic-rich intervals in the offshore areas of the basin. The highest GR values are interpreted to be related with the maximum flooding intervals previously recognised in the evolution of the Sinemurian and Pliensbachian carbonate deposits in the western Iberia margin.

THE PALAEOENVIRONMENTAL DEVELOPMENT OF MIDDLE-LATE PLEISTOCENE GURLEK-KOCABAŞ AND ORTULU TRAVERTINE DEPOSITS (SW-TURKEY)

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Denizli and Acigöl Basins are situated in two adjacent grabens which developed during the Neotectonic extensional period of SW-Turkey. These grabens possess spectacular continental carbonate precipitations (i.e. travertine, tufa) which formed throughout margins of them. Investigated areas are Gürlek-Kocabaş and Örtülü travertines located in the Denizli (NW-trending) and Acigöl (NE-trending) grabens, respectively. In this study, Middle-Late Pleistocene Gürlek-Kocabaş and Örtülü travertine deposits precipitated at the margin of these grabens have been aimed at comparison with palaeoenvironmental evolution.

The Gürlek-Kocabaş travertine lithotypes are mainly composed of laminated, gas bubbles, reeds, paper-thin raft, intraclast and extra-formational breccias. These lithotypes characterize marsh-pool and flatpool facies which deposited in shallow-lake or depression depositional system. On the other hand, Örtülü travertine deposits are characterized by laminated, reeds, intraclasts, extra-formational breccias, crystalline crust and shrubs lithotypes. The lithotypes indicate smooth slope and terraced slope facies formed in slope depositional system which is related to higher flowing energy. In addition, flat-pool and shrub-flat facies are also partly observed in Örtülü travertine deposits which formed turbulated shallow-lake or depression depositional system. Palaeosol levels and pebbly mudstones are quite common detrital inputs among travertine accumulations. Palynomorphs represented by gymnosperm and herbal angiosperm pollen are scarcely observed in the travertine samples, however these microfloral elements abundant in the palaeosol samples in the

Örtülü travertine deposits. Palynoflora defined in the palaeosol level is especially characterized by herb species (Poaceae, Asteraceae-Tubuliflorea, *Artemisia*, Asteraceae-Cichorioideae-liguliflorеae, *Polygonum persicaria*, Geraniaceae and Chenopodiaceae). Besides, angiosperm (i.e. *Quercus, Castanea*) and gymnosperm pollen (i.e. Pinaceae, *Cedrus*) are accompanied with these species in the samples. Non pollen palynomorphs and other organic mate-rial abundantly recorded. This palynofloral data indicates that cold and dry climatic condition could be occurred during the deposition of palaeosol levels.

According to U/Th dating, Örtülü travertine accumulations ceased approximately 308 ka ago and later travertine precipitations laterally pass to fluvial tufa deposits to the Acigöl graben. Moreover, GürlekKocabaş travertine deposits continued to precipitate until 85 ka. The differences of these travertine accumulations are the most probably related with hydrothermal water input controlled by tectonic activity during Neotectonic period.

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INFLUENCE OF CLAY ON CHALK DIAGENESIS

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Understanding the influence of marly layers in Chalk has become increasingly important since they evidently impact diagenesis of the surrounding chalk and thereby porosity and permeability. In the upper Maastrichtian of the Danish basin, it is possible to distinguish two different marly units: Rørdal Mb. and Kjølby Gaard Marl. They both consist of alternating relatively pure chalk and marly layers. In the present study we investigate these intervals in a shallow core, Dalbyover-1, drilled in the central axis of the Danish-Norwegian basin in northern Jylland. Visual inspection of the core have been supplemented by X-Ray Diffractometry (XRD) analysis of the insoluble residues in order to determine the exact mineralogy of the clay; ^{13}C and ^{18}O isotope geochemistry to highlight differences between the layers; isotopic value of ^{34}S and its concentration to evaluate the presence of bacterial activity during the sediment burial, porosity and permeability data and extensive investigations of the microfabric using Scanning Electronic Microscopy (SEM) on non-polished rock surfaces. The integrated dataset allowed us to propose a model where $CaCO_3$ was exported from the marls and partly reprecipitated in the chalk during early burial. This process, correlated with changes in the mineralogical phases present (i.e. clay, pyrite, dolomite) lead to change in petrophysical property.

LINKING HIGH RESOLUTION SEISMIC, GEOLOGY AND PHOTOGRAMMETRY OF THE MAASTRICHTIAN CHALK, STEVNS KLINT, DENMARK

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Modelling of chalk from an oil production perspective represents a large challenge due to the sudden changes of petrophysical properties, related to factors like microfabric variation, silicification and clay content. The problem cannot be addressed thoroughly by core sampling and offshore seismic mapping because limitations in seismic resolution and availability of rock samples. Therefore, we have developed an approach that relies on detailed investigations of onshore reservoir analogous rocks where seismic acquisition can be combined with data collection in adjacent cliff or quarry surfaces. The well-exposed, coastal cliffs of Stevns Klint, Denmark constitute a perfect location to directly correlate high-resolution seismic data with the geological and petrophysical information of the chalk due to the possibility to sample vertically and horizontally along the cliff. Parallel to the cliff, we have acquired two 500 m long high resolution seismic lines using both Pand S-wave acquisition techniques. Furthermore, we collected samples from the cliff walls that were investigated in order to describe the microfabric with the Scanning Electron Microscope (SEM) and obtain petrophysical information. Due to the narrow beach present and the hanging blocks of rock over it we used photogrammetry methods to do the interpretation of the outcrop architecture.

ECHO-CHARACTER MAPPING OF A CONTOURITIC DEPOSITIONAL SYSTEM ON THE DEMERARA MARGINAL PLATEAU

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The Demerara plateau forms a bathymetric indentation along the French Guiana and Surinam margin, defined as a marginal plateau related to a polyphased rifting history. This relief is composed by a continental shelf followed by a slowly deepening plateau between 200-3200 m of water depth. The distal part of this plateau is delimited by the continental slope toward the abyssal plain. The marginal plateau is divided into 4 domains: the upper plateau (200-1500 m), the headscarp slope failure domain (ranging between 1200-1500 m), the intermediate plateau (1500-2500 m), and the lower plateau (2500-3200 m). In the aim to understand the sedimentary processes, the IGUANES cruise, organised in 2013, combined program of geophysical acquisition (Sub-Bottom Profiler SBP or chirp, bathymetry), and sedimentary coring (20 pistoncores). This contribution presents the combined analysis of bathymetric, and SBP data (morphostructural analysis, isopach maps and echo-character facies mapping) and the calibrations of geophysical observations by core data.

The upper plateau is very flat, devoid of seafloor structures, and separated from the intermediate plateau by a 350 km long slope failure headscarp. In contrast, many seafloor structures occur on the intermediate and lower plateau: giant comet tails (the biggest: 4500 m long, 800 m large, 49 m of deep) and longitudinal waves, all NW-SE parallel to the NADW current direction.

The echo-facies analysis calibrated by litho-facies illustrates the different ongoing sedimentary processes. The upper plateau is characterized by hemipelagic sedimentation with muddy litho-facies and bedded echo-facies. The isopach map, deduced from SBP data, shows a longitudinal distribution pattern on the intermediate and lower plateau. Along the headscarp slope failure, the sedimentary accumulation is very thin to absent forming a contourite moat. This moat is characterized by transparent to hyperbolic echo-facies or locally overain by bedded stratifications above transparent to hyperbolic echo-facies. The transparent hyperbolic echo-facies has been reached by cores. It corresponds to a carbonated litho-facies Upper Oligocene in age interpreted as a mass transport deposit (MTD). The giant comet tails observed on bathymetry develop on top of this outcropping MTD. Laterally, this MTD can be covered by fine sedimentation alternating muddy/ sandy facies. Further downslope, a longitudinal sedimentary accumulation shows a wavy bedded echo-facies expressed on the seafloor by longitudinal waves. The litho-facies associated with this echo-facies is constituted by an alternation of muddy and sandy beds showing coarsening and thinning upward sequences. This accumulation corresponds to a separated elongated mounded drift. The lower plateau is characterized on chirp by a low sediment accumulation, with bedded echo-facies associated with sandy/muddy litho-facies. The sediments thin gradually downslope and show internal erosional and no-depositional surfaces suggesting the development of a second moat on the distal plateau. These results indicate that recent sedimentation of the Demerara plateau is dominated by contouritic and slope instability processes. Contourite deposition is favoured by the bathymetric indentation that allows intensification of the NADW. The variations of sediment accumulation (high with low winnowing effect and erosion during high winnowing effect) can influence the pressure in the sedimentary column and then the sediment stability.

FORMATION AND EVOLUTION OF A GLAUCONITE-RICH CONTOURITE DEPOSITIONAL SYSTEM ON THE MARGINAL EMERARA PLATEAU (FRENCH GUIANA, SURINAM)

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The Demerara plateau forms a promontory along the French Guiana and Surinam margin. It is defined as a marginal plateau related to a polyphased rifting history. This relief is composed by a continental shelf followed by a slowly deepening plateau between 200-3200 m of water depth. The distal part of this plateau is delimited by the continental slope deepening toward the abyssal plain. This relief is tought to influence the bottom current intensity and being at the origin of the contourites formation. The contourite deposits are recently described and it is generally constituted by about 24 % of clays, 70 % of silts and 6 % of foraminifer-rich sand. The very peculiar feature is the occurrence of glauconitic grains, which account in some samples to up to 13 % of the bulk sediment and 90 % of the sandy fraction, mainly found filling the foraminifer tests.

Inside those tests, neoformation of Fe-smectite and interstratified smectite/glauconite can occur during early diagenetic redox processes. During the first stage, thanks to a low sediment accumulation rate (induced by the winnowing effect), the formation of authigenic Fe-smectite leads to sequestration of iron and potassium. This process is faster for Fe than for K. If the grains stay during sufficiently long-time at the sea/sediment interface, seawater K continues to be incorporated, hence leading formation of interstratified Fe-smectite/illite (glauconite). The subsequent phases neoformation are also suggested by evolving pigmentation of glauconitic grains from light green to dark green. Both the degree of maturity of glauconitic grains and their chemical composition are likely related to the current intensity: high current intensity with high winnowing effect and low sedimentary accumulation favour glauconitisation. Thus, we suggest that the occurrence of glauconitic grains and their geochemical characteristics, when they are found in contourite sediments, might be an efficient tool for estimating the intensity of bottom currents that shape the oceanic deposits.

We have used this new approach for characterising the contouritic sediments of the Demerara plateau that are mainly under the influence of NADW with variable strength during global climate shifts (glacial and interglacial phases). In this area, the glauconite formation is allowed because of significant supply of elements such as Fe, favoured by strong continental leaching under the tropical conditions. Our results indicate that during glacial periods, the glauconitic formation and maturity is higher than during interglacial periods, suggesting an increase of the NADW intensity during ice periods along the French Guiana margins, inducing a strong bottom winnowing and, consequently, a strongly reduced accumulation rate.

QUATERNARY LANDFORM DEVELOPMENTS AND CLIMATIC VARIABILITY IN TECTONICALLY ACTIVE REGION OF CENTRAL KUMAUN HIMALAYA, INDIA

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The fluvial landforms in the Saryu, Pindar, Ramganga, Goriganga and Kali river valleys of central Kumaun Himalayan region, were investigated to understand the role of temporal variability in climate and the spatial changes in crustal deformation. In present work we employed geomorphological, sedimentological, geochemical concepts, supported by optical dating. The monsoon and glacial dominating rivers in Himalaya are the best achieves that preserve the records of past climate and tectonic processes. These river valleys have been preserved cut-and-fill terraces with thick alluvial cover, debris flow terraces, bedrock strath terraces, and fossil valleys associated with epigenetic gorges that provide signatures of tectonic activity and climate. The available chronological and sedimentological records from Pindar, Saryu and Kosi river basins suggests that the oldest phase of aggradation within these basins occurred between 33 and 45 ka, during relatively strengthened ISM corresponding to the later part of pluvial Marine Isotopic Stage-3 (MIS-3). However, the sedimentation impersistently continued until and around 21 ka, during the declining phase of the ISM. The major phase of valley fill is dated between 13 and 22 ka. The youngest phase of aggradation is dated at early and mid-Holocene (9-3 ka) represents the transitional climate during which sporadic high sediment fluxes both from the upper catchment and tributary streams led to the development of fossil valleys. The geochemical analysis of sediments helps to distinguish and estimate the amount of sediment derived from the source rocks and consequently provides rate of erosion. The differences in the sediment composition are finally transferred from the bedrock by rivers and deposited towards the lower reaches, which help us in understanding their source and the rate of erodibility of the rocks. The sediment dispersal along the valley and geochemical analysis provides us the period of high and low precipitation, which can cause the large scale deposition. The sedimentological, geochemical and chronological study together suggests that the sediments within these basins are primarily regulated by monsoon precipitation and glacial melt. However, the post depositional landform modification is modulated by enhance tectonic forcing.

PLIO-QUATERNARY SLOPE PROCESSES IN A COOL-WATER CARBONATE RAMP SETTING: PRELIMINARY RESULTS FROM THE BIGHT BASIN, AUSTRALIA

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Deepwater carbonate slope environments are less understood than their silicicastic counterparts in terms of relating sedimentary processes to the resulting stratigraphic architecture. While it is acknowledged that they form complex systems influenced by the interplay between upslope carbonate production (type/ rate), tectonic activity and climatic and eustatic changes, modern analogues are sparse (and mostly focus on tropical margins) and more research is needed to fully understand the sedimentatary processes and resulting depositional architecture in those settings.

The Bight Basin represents one of Australia's frontier hydrocarbon regions situated along the country's southern margin. It is an example of a deepwater slope-basin system initiated during a period of Middle Jurassic to Early Cretaceous upper crustal extension. This study focuses on the Pliocene Quaternary deepwater, cool-water carbonates (~3000 m depths) and the sedimentary processes affecting the seabed morphology, which previously, have not been extensively examined. This study is being undertaken as part of the Great Australian Bight Research Program, a multidisciplinary collaboration between Chevron, Commonwealth Scientific & Industrial Research Organization (CSIRO), the University of Western Australia, as well as other Australian Universities and Museums.

The slope processes are investigated through the integration of existing open-file multidisciplinary regional datasets and recently acquired high-resolution multibeam bathymetry, sub-bottom profiles, piston cores, rock samples and over 30,000 km^2 of high-resolution 3D seismic data. The availability of this integrated dataset means that for the first time, the Bight Basin's near seabed sedimentology and geomorphology can be examined.

Here 3D seismic data was used to map the seabed and subsurface stratigraphic surfaces along which key seismic attributes were computed. These analyses revealed the recent to modern submarine geomorphology of this deepwater carbonate slope system. Combined with multibeam and high-resolution SubBottom Profiler (SBP120) seismic, the data revealed previously unknown geomorphological features in the area. These results shed new light on recent slope processes in the Bight Basin, which provide a unique insight into carbonate-dominated gravity current processes in cool-water margins. Key results include:

(a) the widespread occurrence of cyclic steps (upstream-migrating, upper-flow-regime bedforms) suggesting the occurrence of internal hydraulic jumps in turbidity currents;

(b) mass-transport deposits such as slumps and slides identified by detailed 3D seismic analysis; and

(c) the interaction between turbidity current processes with recent submarine volcanism.

The results from this study contribute to the understanding of depositional processes along a coo-lwater carbonate slope system, and bring new insights in the Cenozoic sedimentological history and stratigraphic architecture of the Bight Basin.

ROUNDNESS AND SEDIMENTARY FACIES IN A LARGE FLUVIAL FAN FROM THE TRIASSIC BAI FORMATION, JUNNGAR BASIN, XINJIANG, CHINA

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Gravel roundness is one of the simple but crucial parameters in particle shape, which denotes the abrasion degree of gravel corners. It is related to the transportation and deposition of sediments. In this paper, we propose a new idea by roundness quantitative analysis, to indicate the sedimentary facies and transporting process as a supplementary parameter.

Mahu Sag, located in northern Junggar Basin, Xinjiang Province, China, is chosen for this study. Strata of Triassic Baikouquan Formation were deposited in a large-scale fluvial fan to fan delta system, extended for about 30 km. It is dominated by conglomerate, ranging from granule to cobble. According to the observation and description of cores, 5 microfacies in coarse grains are identified: (i) debris flow, (ii) intermittent channel, (iii) ephemeral channel, (iv) underwater debris flow, and (v) underwater distributary channel. From the above, (i), (ii) and (iii) are deposited in fluvial fan plain, (iv) and (v) are deposited in fan delta front. Excellent massive conglomerates of this Formation allow the systematically vertical characterization of roundness.

The process is implemented in a De-flat algorithm, which is based on Cox's circularity formula. In this way, two parameters are calculated to manifest the rounding degree of any measuring unit: (i) roundness value, and (ii) corresponding variance value, which portrays variable susceptibility to roundness.

We compared roundness and its variance curves of several microfacies. The data indicate that the average value of roundness in these microfacies show a moderate change around 0.519, from subrounded to sub-angular. Vertically, the data of underwater distributary channel increase upward. In particular, the average of their variance for debris flow from both the fluvial fan and fan delta samples are generally larger than the samples from channel deposit, 0.03899, 0.01267, 0.02511, 0.03300 and 0.02810 for the variance of (i) to (v) respectively. It appears that the variance of rounding is likely to indicate clastic particles' transportation, especially in transport forces and components. When the variance of sediments is high, gravity flow would be the main mode of transport and deposit, with multi-time moving components. By contrast, when it gets low, the sediments would be formed by traction currents or gravity flow, with a short-distance single-time or long-distance multi-time moving components. It should be noted that the variance of rounding is likely not the indispensable parameter to transporting process, but rather as a supplementary tool to verify.

The results of this study show that the method of roundness and associated variance can effectively distinguish different types of sedimentary processes, which make roundness more geologically meaningful. However, such a parameter would require a more comprehensive data to apply in other depositional system.

PROVENANCE OF THE UPPER CRETACEOUS LANGE-LYSING DEEP-MARINE SANDSTONE IN THE NORWEGIAN SEA: WITH IMPLICATIONS FOR RESERVOIR QUALITY

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The provenance and reservoir properties of Upper Cretaceous Lange-Lysing sandstone in the Norwegian Sea has been determined by using integrated whole-rock geochemical, petrographic and detrital zircon U-Pb age dating by LA-ICPMS. Petrographic and geochemical data indicate that the sand was derived from granitic-gneissic areas with subordinate recycled orogenic provenance derived from quartzose and (meta) sedimentary rocks. Three different provenance signatures are revealed within three geographical areas containing the Lange-Lysing succession. They have contributed to significant response on diagenesis, which gives implication for reservoir properties, whereby the petrographic data expose several controls on porosity development, including textural and mineralogical factors. (1) Quartzofeldspatic petrofacies in the Møre Margin is interpreted to have the highest potential as hydrocarbon reservoir due to good sorting and large grain size, combined with preservation of intergranular and intragranular porosity, not occluded by cement. The zircon grains were derived from felsic sources in the Western Gneiss Region of Baltica, due to a prominent age peak that closely corresponds with the Sveoconorwegian (1000-950 Ma) and the Gothian orogenies (1700-1500 Ma). (2) Sandstone of the quartzolithic petrofacies from the Halten-Dønna Terrace has smaller grain size and is less sorted than the quartzofeldspatic petrofacies, yielding a lower reservoir quality. The detritus is suggested to have been sourced from more mixed? andesitic-felsic rocks. The zircon grains derived from the Paleozoic Caledonian Nappe Domain of western Baltica and from the Lofoten Islands or Western Tromsø Base-ment Complex in northern Norway because of a dominance of Early Proterozoic crust-forming zircon grains (1800-1750 Ma) and an Archean component. (3) The main diagenetic features of the quartzarenite petrofacies in the deeper Vøring Basin includes mechanical and chemical compaction, precipitation and replacement of quartz overgrowth, kaolinite, clay minerals, iron oxide and formation of secondary porosity due to dissolution of labile minerals. Grain coating of authigenic clay minerals exerts a critical control on the reservoir quality as is inhibits quartz cement. The Vøring basin has decreasing reservoir quality with burial depth linked to the precipitation of pore-filling kaolinite, clay minerals and clay microporosity. The deposits are inferred to have mixed sand distribution from the eastern Greenland and the Norwegian margins based on wide zircon-age spectra with predominance of Early Proterozoic (1900-2100 Ma) and Archean contribution (> 2600 Ma). Contradictory to previous studies, the U-Pb analysis of the Lange-Lysing sandstone has proved that Late Archean zircon is present within deposits derived from the Norwegian landmass. Furthermore, the study stresses a strong correlation between provenance, diagenetic products and reservoir quality.

DIAGENETIC AND PORE-TYPE SIGNATURE OF A LONG-TERM SUBAERIAL EXPOSURE EVENT IN AN ISOLATED CARBONATE BUILDUP (UPPER BURMAN FORMATION, MIOCENE, OFFSHORE MYANMAR)

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The integration of detailed petrographic analysis of carbonate rocks and carbon/oxygen isotope ratio measurements provided new insights into the diagenetic history of the Burman (UBL) carbonate platform. The studied formation is developed as a high to moderate energy isolated buildup. Carbonate production is dominated by coralline algae, larger benthic foraminifera and scattered corals. The high (28%) average porosity of the platform is dominantly related to microporosity, moldic and vuggy porosity. Karstic features are evidenced in cores and by significant mud losses during drilling. Petrographic and stable isotope analyses support the fact that both microporosity development and blocky calcite cementation occurred in a shallow burial, meteoric diagenetic environment. 3D seismic data revealed that the UBL is topped by a highly erosive unconformity interpreted as a major subaerial exposure surface. The platform is capped by Late Miocene marine siliciclastic deposits. The estimated time-hiatus between platform formation and overlying siliciclastics is approximately 15 million years. The lack of subaerial exposure evidenced within the core mass strongly suggests that microporosity development and non-selective dissolution (vuggy porosity development and karstification) are related to the long-term subaerial exposure that occurred at top. The vertical distribution of meteoric diagenetic features is interpreted as a function of Mid-Upper Miocene relative sea-level variations.

PLATFORM-TO-BASIN TRANSECT OF THE URGONIAN PROVENCE CARBONATE PLATFORM (BARREMIAN–APTIAN, SE FRANCE): NEW INSIGHT INTO THE REGIONAL TO GLOBAL MECHANISMS DRIVING THE LOCAL STRATIGRAPHIC ARCHITECTURE

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In-depth investigation of stratigraphic correlations, facies and thickness variations across the Late Barremian-Early Aptian Urgonian Provence platform (SE France) provides insight into the key role of synsedimentary tectonics in its architecture and evolution. In the Monts de Vaucluse domain, detailed mapping of the successive stratigraphic sequences shows that facies belts are consistently distributed along an approximately N120 direction. This latter is in accordance with the dextral, strike-slip E-W to NW-SE Provençal faulting pattern which indicates that the extension of the Urgonian platform toward the Vocontian basin is primarily controlled by these structurations. Development of N120 trending high-energy shoals during the Upper Barremian *Imerites giraudi* Zone drowning tends to demonstrate that this faulting direction may also define a succession of local, punctual topographic highs possibly acting as physiographical boundaries and delimiting deeper areas. Moreover, initiation of rapidly varying spatial and temporal subsidence across the platform domain is closely related to the progressive collapse of the South Provence domain (at the *G. sartousiana–I. giraudi* zones boundary) which in turn is considered as coeval with the rotation of Iberia and the correlative opening of the Bay of Biscay. Revised chronostratigraphy and biostratigraphy of the Urgonian Provence platform provides an integrated framework by which consistent platform-to-basin correlations are made. It results that 1) the orbitolinid-rich beds and subsequent caprinid-bearing unit of the North Provence Platform are time-equivalent of the organic-rich Taxy episodes occurring in the drowning sequence of the Bedoulian-type area and 2) the OAE 1a culmination is recorded in the marly cover of the Urgonian platform. Furthermore, supra-regional correlations suggest a quasi-synchronous collapse of adjacent Urgonian platforms (i.e. northern Tethyan margins), thus questioning the role of global mechanisms (e.g. eustatism, climate) in the demise of the Urgonian regime whose timing is actually older (i.e. Late Barremian *M. sarasini* subzone) than previously assumed.

UNDERSTANDING THE GEOCHEMICAL SIGNATURES ALONG A BARREMIAN–APTIAN PLATFORM-TO-BASIN TRANSECT (URGONIAN CARBONATE PLATFORM, PROVENCE, SE FRANCE): IMPLICATIONS FOR REGIONAL CORRELATIONS

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In shallow-water carbonate environments, the resolution of biostratigraphy is frequently not sufficient to build a high-resolution stratigraphic architecture. Over the last decades, chemostratigraphy has become a powerful tool often used to establish long-distance correlations across proximal and distal settings but its reliability has recently been questioned regarding both the lack of biostratigraphic control and the impact of diagenesis on isotope records.

The ammonite-calibrated platform-to-basin transect of the Late Barremian–Lower Aptian Provence platform is made particularly relevant to challenge chemostratigratigraphy-based correlation methods in shallow carbonate series at different scales.

High-resolution systematic $\delta^{13}C$–$\delta^{18}O$ bulk-rock analyses have been done on stratigraphic sections representing the different platform environments. Particular focus on the isotopic signatures of the discontinuity topping the caprinid-bearing Urgonian series support a subaerial exposure event and suggest a link between carbon shift intensity and location within the platform.

Preservation of primary signal in shallow-water to outer-platform facies is also hampered by the polyphased diagenetic evolution. Indeed, petrographic and poroperm data indicate that reservoir prone microporous facies, derived from shallow-burial meteoric diagenesis, lower the carbon values; contrasting observations arise from tight units resulting from early marine cementation and exhibiting higher values for a same depositional facies.

Although basinal series are more likely to preserve primary geochemical signals, extreme values for carbon and oxygen isotopes are observed in correspondence with fine-grained bioclastic material input originating from the adjacent platform and following the final demise of the rudist-dominated platform dated to the late Barremian *Imerites giraudi* Zone.

In line with recent works, the results of this study suggest that chemostratigraphy may not constitute a suitable tool for correlating Urgonian shallow-water series at local scale, and further question the relevance of interregional correlations at the Barremian–Aptian transition.

SANDSPIT EVOLUTION IN MACROTIDAL SETTINGS. A COMPARATIVE STUDY

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Coastal barriers have been intensively studied since they constitute natural protections against wave attack and marine submersion. In a context of climate change and sea-level rise acceleration, understanding their future development is critically. Here we present the main results of a research project that aimed in reconstructing and comparing the evolution of two sandy barriers (sandspits). The originality of the study was to examine sandspits located along macrotidal coasts since most barriers are considered in their context of wave-built sedimentary bodies.

In order to examine when and how these sandspits developed, a stratigraphic reconstruction based on ground penetrating radar (GPR) investigations were performed, completed with vibrocore acquisitions for sediment facies analyses, GPR ground-truthing, and chronology. Historical land and sea charts were used to refine the time frame of evolution.

To be able to infer the role of tides vs. wave climate in sandspit evolution, two sandspits subject to significant difference in tidal ranges were studied. The Saint-Germain spit (NW France, English Channel coast, tidal range up to 14 m); The Arcay spit (SW France, Atlantic Ocean coast, tidal range up to 7 m). Both sites are influenced by relatively similar low to moderate wave dynamics (Hs~0.5 m).

The comparison of historical charts demonstrates that the formation of the two spits occurred between 1650 and 1700 AD, within the period of the Little Ice Age (LIA). Our study suggests that LIA climate conditions (enhanced storm and wind activities) were favourable for spit formation. Despite the convergence in time of formation, the depositional history of the two spits differs significantly. It appears that the Arcay spit experienced a regular elongation that is still ongoing today. On the contrary, the evolution of Saint-Germain spit was periodic and very fast. Already about 1750 AD it reached its current extension and morphology, suggesting that in half a century or maybe less, the entire spit formed.

The GPR and core data reflect these contrasted evolutions of the spits. Data from Arçay demonstrate that the spit complex is mainly made of three wave-dominated units (spit platform, beach, washover) and evidence a dominant shore-parallel mode of construction. ^{14}C ages for Arcay spit are consistent with an onset of construction during the 1600 s. Data from the Saint-Germain spit display two main units that are respectively tide-dominated (estuary, embayment) and mixed tide, wave and wind-influenced (sand spit body). ^{14}C and OSL ages constrain the onset of sandspit formation to around 1000 years ago, and the most recent sand construction, around 400 years ago. The Saint-Germain spit complex results both from a vertical and progradational / longshore accretion.

Differences in sediment supply are assumed to explain these two contrasted construction modes (quick progradational vs progressive longshore mode). This difference can be partly related to tidal ranges. Sand fluxes, both wave and wind-induced, are much higher on hypertidal sites, with large intertidal foreshore/flats, than those on macrotidal beaches. This difference was probably enhanced during the severe wind conditions of the LIA.

DIACHRONISM OF KEY FOSSIL STRATIGRAPHIC MARKERS IN THE MESOZOIC: CONSEQUENCES FOR THE GEOLOGIC TIME SCALE AND FOR PALEOENVIRONMENTAL CHANGE

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Diachronism is a well-known issue in stratigraphy. In the case of various macro-and microfossil groups, several statistical methods such as constrained optimization (CONOP) or unitary associations have been proposed to remedy such issues and improve the Geologic Time Scale. The purpose of the latter methods is to examine misfits, eliminate problematic bio-events in favor of the most reliable biostratigraphic markers and to draw the best statistical or optimal biostratigraphic series. Such methods do not attempt, however, to quantify diachronism nor to understand its possible causes besides issues linked to preservation, inadequate sampling or incorrect dating. The integration of numerous stratigraphic techniques (chemostratigraphy, magnetostratigraphy, high-precision radiometric dating and cyclostratigraphy) allows today a much better characterization of potential diachronism in some of the key stratigraphic macro-and microfossil marine groups. Here, we will examine case-studies from the Mesozoic where well-demonstrated examples of diachronism call for a modification of some of the "standard" marine microfossil zones but also trace paleoenvironmental change. Rather than to be considered as a pitfall, more emphasis should be put on potential diachronism as it can improve both stratigraphy and our understanding of ocean currents, climate, continent configuration and/or sea-level change.

THE TOARCIAN OCEANIC ANOXIC EVENT OF YORKSHIRE COASTAL OUTCROPS (UK) IN ITS WIDER CONTEXT

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The early Toarcian Oceanic Anoxic Event (or 'Jenkyns Event', at ~183 Ma ago) was characterized by enhanced carbon burial, a prominent negative carbon-isotope excursion (CIE) in marine carbonate and marine and terrestrial organic matter, and other numerous geochemical anomalies. A precursor to the early Toarcian CIE has also been documented at the Pliensbachian/Toarcian (Pl/To) boundary in sections of NW Europe, but its expression in the sedimentary record and possible causes are less well constrained. The Toarcian event is arguably most intensively studied in the Cleveland Basin, UK, whose sedimentary deposits have been litho-, bio-and chemostratigraphically characterized. Here, we present a new set of high-resolution elemental data produced by hand-held X-ray fluorescence analysis to test the expression of redoxsensitive trace metals and detrital elements across the late Pliensbachian to mid-Toarcian of the Cleveland Basin. Detrital elemental concentrations (Al, Si, Ti, Zr) are used as proxies for siliciclastic grain content and, thus sea-level change, and closely match previous sequence stratigraphic interpretations from the Cleveland Basin. The timescale of the event as recorded in the Cleveland Basin is debated, though our new elemental proxies of relative sea level change show evidence for a 360 cm cyclicity that may be indicative of pacing by ~405 kyr eccentricity cycles. Trends in total organic carbon, and from redox-sensitive elements such as S, Fe, and Mo, are in agreement with previous findings and confirm scenarios of widespread ocean deoxygenation across the early Toarcian OAE. Maximum Mo-enrichment immediately following the CIE is a feature that is similar to recent observations from the Paris Basin and a correlation of these trends is proposed here. This correlation suggests a similar oceanic drawdown of this element during the T-OAE in the two basins. However, while this drawdown appears to correlate to a regressive trend across the T-OAE in the Paris Basin, data from Yorkshire point to a transgressive trend at that time, which contradicts the "basin restriction" model of Mo drawdown. The concentration of the element As throughout the Early Toarcian sedimentary record of the Cleveland Basin shows distinct similarities to that of Mo, possibly suggesting a similar substantive drawdown of this element from Early Toarcian seawater, especially during the euxinic conditions that characterise the CIE interval.

RECORD OF PHARMACEUTICAL PRODUCTS IN RIVER SEDIMENTS: A POWERFUL TOOL TO ASSESS THE ENVIRONMENTAL IMPACT OF URBAN MANAGEMENT ?

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The occurrence of eight pharmaceutical products (PPs) from various therapeutic classes (B-Blockers, Psychotropics, Painkillers and Antibiotics) was studied in urban sediments collected upstream a small dam in Orleans, France. Since PPs represent a global contamination since 1950's, their spatial and historical distribution was documented in order to better understand the impact of recent urban management on the chemical quality of sediments.

PPs were detected at different concentrations within two cores. Concentrations mainly ranged between 1 and 10 $ng.g^{-1}$. The chronology of core LOI13-2, based on radionuclides (^{137}Cs and ^{210}Pb), allowed to characterize the impact of the deflection of effluent discharges on the PPs patterns over the last 40 years. It was found that the impact varied depending on each PP and two trends were observed: the first one revealed a strong impact of the effluent deflections from a large wastewater treatment plant in 1989, and the second one with a greater impact of the effluent deflections of 3 smaller wastewater treatment plants between 2003 and 2009. Moreover, the deepest and oldest occurrence of each PP is correlated with its market authorization date, with a few exceptions, indicating that some PPs can be used as chronomarkers over the last 50 years. The recent management of effluent discharges within the watershed improved the chemical quality of these sediments.

However, in view of the persistence of pollution in trapped sediments, estimated at the millstream scale at a total of 763 ± 565g for the selected PPs, questions about their fate in the river ecosystem remain, since these superficial sediments represent a potential downstream source of pollution in case of the removal of a small existing dam.

THE DEAD SEA SUBSURFACE BIOSPHERE AS ANALOG OF MICROBIAL ACTIVITY IN SALT GIANT DEPOSITS

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The Dead Sea is currently one of the largest saline bodies on Earth. It also constitutes a unique and presently active analog for the formation of deep-water evaporitic deposits. Its hypersaline subsurface hosts relatively similar conditions to those observed in “salt giants” such as the Messinian deposits. The Dead Sea Deep Drilling project, an international research initiative under the umbrella of ICDP (International Continental Drilling Project) has allowed to gather invaluable information relative to geological and biological processes occurring in evaporitic subsurface environments. In particular, the geomicrobiogical study of the 450 m long core recovered at the deepest site of the Dead Sea led to the characterization of specific microbial communities, adapted to extreme and precise sedimentary conditions. The study of the DNA currently present in the core, has revealed that similar facies, in particular the most extreme (halite and gypsum deposits) host relatively simple and similar communities dominated by the most halophilic organisms, regardless of depth. This is caused mainly by the conditions of the water column, its stratification and organic matter inputs, that relate directly to the prevailing environmental conditions at the moment of sedimentary deposit. Subsurface microbial communities can thus be used as a proxy for paleoclimatic conditions in the Dead Sea subsurface. As a result, microbial communities have differential effects on given facies. In some facies, methane production is favored while in other, the degradation of organic matter remains incomplete. Such differences result in more intense formations of iron sulphide minerals for example, which may affect the magnetic record and provide information on the cycling of sulfur and iron.

The large sedimentation rates and immense preservation potential of lipids also allowed identifying periods of intense productivity and microbial activity. The discovery of unique biomarkers also led to the identification of unexpected adaptations to lack of nutrients, fresh organic matter and extreme salinity, all environmental conditions that could have been observed during the most intense periods of formation of salt giants.

The study of genomes and biomarkers in these environments both provide valuable information for paleoclimatic and paleoenvironment reconstructions and host an immense potential for the discovery of new microbial pathways related to adaptation to extreme conditions.

CHARACTERISING THE SUBSURFACE: LESSONS FROM THE SHERWOOD SANDSTONE GROUP, UNITED KINGDOM

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The properties and spatial distribution of the Permo-Triassic-aged Sherwood Sandstone Group make it a critical volume of rock in the United Kingdom. It is a principal aquifer, supplying groundwater for industrial and potable supply; the sandstone is a hydrocarbons reservoir offshore and onshore, and it is also a potential host for CO_2 storage. However, its location, overlying several coalfields and beneath major cities and towns has resulted in contamination by processes associated with heavy industry, mining, farming and waste management. An improved understanding of fluid flow in the Sherwood Sandstone Group is therefore required to optimise the management of the rock unit-both to improve contaminant management strategies, and to maximise the economic potential of the sandstone.

This study explores the petrographic heterogeneity within the fluvial Sherwood Sandstone in the little-studied Needwood Basin in central England. A suite of thirty thin sections taken from a range of depositional facies from five boreholes allows optical microscopy and SEM to determine the diagenetic evolution of the sandstone. Porosity was measured from the thin sections using the jPor image analysis method and permeability measurements were taken direct from core samples using a mini-permeameter.

Numerous diagenetic features are described including, eodiagenetic features of calcrete and dolocrete formation, patchy calcite cement, dirt fringes, calcite lithics, and syn-sedimentary deformation. Mesodiagenetic features include compaction, dissolution, mineral replacement, quartz overgrowths, fracture cementation, reduction of iron oxide (bleaching), baryte/fluorite precipitation from percolating fluids and further calcite/dolomite growth. Telodiagenetic features are dominated by framework grain dissolution of feldspar resulting in significant secondary porosity. This additional porosity has subsequently been partially reduced by kaolinite and iron oxides. Initial results indicate that lithofacies does exert a control on diagenesis and subsequent porosity and permeability, which is strongly developed in the pebbly sandstone and low angled cross-bedded facies, and to a lesser extent in the cross-bedded facies. A poor correlation between facies and diagenetic fabrics was observed in samples interpreted as horizontal/near-horizontal facies.

This study shows that primary sandstone deposition appears to influence diagenetic processes, impacting porosity and permeability in some facies. This understanding is relevant to the development of flow and process models that better represent transport through multi-storey fluvial sandbodies with a scale of variability at the sub-seismic scale. This work is therefore relevant to the identification and prediction of potential pathways and baffles through sandstone reservoirs and aquifers.

DEPOSITIONAL ARCHITECTURE, EVOLUTION AND CONTROL PROCESSES OF SUBMARINE CANYON SYSTEM IN THE PEARL RIVER MOUTH BASIN, NORTHERN SOUTH CHINA SEA

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With the continuous improvement of research methods and technologies on deep-water petroleum exploration, submarine canyons have attracted great interests in studying their depositional architectures, stratigraphic frame, geomorphic featrues and source to sink system. As the main passageway of deposits transported from shelf margin to basin and good reservoir of hydrocarbon, submarine canyon systems have been highly regarded by petroleum geologists and sedimentologists.

Based on high-resolution seismic reflection data (2D and 3D) and well log data, the depositional architecture and evolution of the submarine canyon system developed since middle Miocene in Pearl River mouth basin (northern South China Sea) are well documented. Axial channel deposits, channel levee deposits, slumps and lobes are the main architectural elements of the submarine canyon system. According to its external morphology and internal architecture, the submarine canyon system can be divided into three segments from continental shelf to ocean basin, the northern slope segment, the central uplift segment and the Liwan sag segment. In the northern slope segment, multiple straight and shallow slope gullies and slumps sliding from the shelf-margin delta front located north east of study area convergent to the submarine canyon system. Axial channel deposits produce weak-middle continuity, high amplitude reflections, and show “U” or “V” shaped cross-sectional motifson 3-D seismic profiles. Multiple shaped channel bases and abundant channel-levee systems are the main characteristics of the central uplift segment. Three branch channels are identified in the Liwan segment, which characterized by high amplitude, strong continuity axial channel fill. The three segments are erosional, erosional-depositional and depositional channel fill respectively. The root mean square amplitude slice from CSB4-2 to CSB4-4 gives us a clear understanding of the evolution of the whole submarine canyon system: the submarine canyon system experiences a complete cycle of forming, prosperous and atrophy, the outer contour of submarine canyon system remains stable all the way.

The sediment supply, subsidence of the Baiyun sag, activity of syngenetic faults along shelf margin and paleo-geomorphology are considered to be the main control factors on the evolution of the submarine canyon system. Abundant sediment supply is the material foundation of the development of the submarine canyon system, the rapid subsidence of Baiyun sag since middle Miocene provides the transport path of sediments and slope condition, the activity of syngenetic faults is the driving force of shelf-margin deposits’ slide, while the paleo-geomorphology restricts the orientation and outline of the submarine canyon system.

COLD-WATER CORAL PRESERVATION PATTERNS IN CORAL MOUNDS EVALUATED BY COMPUTED TOMOGRAPHY: STATE OF THE ART AND FUTURE PERSPECTIVES

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Since the first commercially available computed tomography device (CT) was installed in a hospital in 1972, CT developed quickly to a standard diagnostic tool in medicine. Soon afterwards, first attempts were undertaken to use this non-destructive technique in other research disciplines. In cold-water coral (CWC) related research, CT analyses have been used for the visualisation of CWC preservation patterns within coral mounds and bioerosion patterns within coral skeletons (by microCT). The identification of CWC preservation patterns in coral mounds were recently improved by the quantification of the coral content, the matrix sediment x-ray density, and the CWC clast size and orientation. This highlights the potential of quantitative CT analyses in geo-biological research. The incorporation of coral growth-orientations and the supervised classification of the main coral species and other associated organisms present promising goals for future developments in CT processing to improve our understanding of coral mound development through time.

PALEOHYDROLOGY RECONSTRUCTION OF THE STROMATOLITES OF THE BACALAR LAGOON

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The stromatolites are organosedimentary carbonate deposits formed from the interaction between benthic microbial communities and detrital sediments. Microbialites have played an important role in the early history of life in the Earth. The microbialites growth depends on the physic-chemical conditions, and it's possible to link the environmental conditions to the sedimentary record. These structures are present worldwide; and the Bacalar lagoon microbialites, in the Mexican Caribbean are one of the largest freshwater stromatolites occurrences, with variable morphologies due to the dynamic and composition of the lagoon. The Bacalar lagoon is facing to anthropogenic activities derived from the tourism and economic activities. The changes in the composition of water column derived from anthropogenic activities and the natural changes from the system will be record in this work.

The stromatolites of the Bacalar lagoon are particularly important, because they preserve past information about the climatic and life conditions at their sedimentation instant. The sedimentary record analysis can allow to realize a paleohydrology reconstruction, and to know how the Bacalar lagoon have changed through the time, in terms of the chemical composition, changes in temperature and precipitation (climate change), the groundwater contribution and other factors.

Six cores samples of the stromatolites were collected in the southwest part of the lagoon. In order to assess the quality in the area of the collected cores, sediment and water samples were also collected. To establish the chronology of the lacustrine sequence, the cores were dated through AMS ^{14}C, the stable isotopes as ^{18}O and ^{13}C were analyzed in the sediment samples. Additionally, it was determined the concentration of trace elements and the content of the minerals through the analysis of the X-Ray diffraction (XRD). To water characterization, the pH, temperature, dissolved oxygen, conductivity, alkalinity, nutrients, major and trace elements concentration were determined. With the analysis we can infer the factors of regulation and behavior patters. The analyses were performed at the CICY, A.C., at the University of California Santa Cruz and at the UNAM.

The Bacalar lagoon does not have a regulation like protected area, and the tourism and economic activities are impacting the ecosystem. Through this investigation the changes in the composition and dynamic of the lagoon can be highlighted, and some projections (climatic, recharge and anthropogenic) can be establish in an invaluable lagoon of the Mexican Caribbean.

TRANSFERRING SEDIMENT SUPPLY SIGNALS TO THE FLUVIAL STRATIGRAPHIC RECORD

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The stratigraphic record is a unique physical archive for past climate and tectonic conditions on Earth and other planetary bodies. These forcing and boundary conditions set the rate and volume of sediment delivered to sedimentary basins, which can be, theoretically, linked back to the stratigraphic record. However, for sediment supply signals to make their way through to stratigraphy they must pass through the active layer of the Earth's surface, which is scaled to channel depth. Within this surface layer, temporary deposition and erosion by an autogenically changing network of channels may complicate signal transfer and storage. For the long-term, the likelihood of signal transfer taking place can be evaluated using a vertical time-scale of stochastic autogenics. The current study makes use of physical experiments conducted in the Tulane Delta Basin that differ from each other in their supply rate curve. Using the known boundary conditions of the experiments, we can test whether cyclic sediment supply to an experimental delta will influence morphodynamics and if so, how this can be recovered from synthetic and physical stratigraphic datasets collected during the experiments. Different metrics to analyse the dataset show that supply signals will be modified and can even be destroyed by their interaction with autogenic processes on the delta. Transfer of a supply cycle to stratigraphy depends on the duration and magnitude of the signal and shows different characteristics for short and long period changes, which is predicted by our theoretical framework for channelized systems. The theoretical approach may be applied to field stratigraphy and used to guide more reliable interpretation of ancient sediment supply signals.

ACIDIFICATION PROCESSES IN A PERITIDAL CARBONATE SUCCESSION ACROSS THE TRIASSIC/JURASSIC BOUNDARY (SICILY)

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For the first time, a correlation between biostratigraphic events and $\delta^{13}C$ curve was attempted along an UpperTriassic-Lower Jurassic peritidal limestone succession cropping out in westernmost Sicily. The peritidal carbonates are organized in shallowing upward cycles characterized by subtidal skeletal mudstone to grainstone, intertidal microbial mats and supratidal paleosoils. About 300 meters of this succession covering the Triassic-Jurassic interval were studied in details.

On the base of the macro-and microfossil assemblages from the subtidal facies, four informal units have been recognized along the studied section. Unit R1 (at the base, 111 m thick) is dominated by large megalodonts, rare coral carpets (*Retiophyllia* sp.), calcareous algae and the well-known Rhaetian benthic foraminifer association (among which *Triasina hantkeni*, *Aulotuortus sinuosus*, *Auloconus permodiscoides*). The base of unit R2 (129 m thick) is placed in correspondence of the abrupt disappearance of the large megalodontids that are replaced by smaller and rare specimens, but with no variations of the benthic foraminifer community as compared to R1. Unit R3 (50 m thick) records the disappearance of the small megalodontids but the persistence of the Rhaetian foraminifers, while the overlying unit H1 (10 m thick) records the total disappearance of the typical Rhaetian foraminifers and their replacement by an oligotipic assemblage with *Thaumatoporella parvovesiculifera* and *Aeolisaccus* sp. The boundary between unit R3 and H1 is assumed as a proxy of the Triassic/Jurassic boundary (TJB).

The carbon curve trend was estimated in bulk calcitic samples collected in the upper part of the studied section (ca. 224 m thick) that covers the TJB. The $\delta^{13}C$ curve is very jagged and two main negative excursions interpreted as “initial” and “main” CIEs have been identified in the upper zone of the Rhaetian beds. The obtained carbon signature is comparable to two (“initial” and “main”) of the three negative CIEs recorded in Late Triassic worldwide as a consequence of the high CO_2 rates related to CAMP volcanism.

In particular, we observed a straight correspondence between the extinction events and the recorded negative carbon isotope excursions. In details, the first (“initial”) CIE matches the disappearance of the large megalodontids and corals. The beginning of the second (“main”) CIE corresponds to the last occurrence of small megalodontids and calcareous algae, whilst the end is associated to the extinction of the Rhaetian foraminifer community. After this second negative carbon isotope excursions (i.e. “main”) a positive trend (ca. +1 ‰) is recorded upward, which is also associated to the bloom of *Thaumatoporella parvovesiculifera* and the gradual recovery of the carbonate factory in the Hettangian beds.

SEDIMENTOLOGY AND OCEANOGRAPHY OF EARLY ORDOVICIAN IRONSTONE, BELL ISLAND, NEWFOUNDLAND: FERRUGINOUS SEAWATER AND UPWELLING IN THE RHEIC OCEAN

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Early Ordovician ironstone of the Bell Island and Wabana groups, Bell Island, Newfoundland provides new information regarding the biogeochemical cycling of Fe and P just prior to the onset of the Great Ordovician Biodiversifiction Event (GOBE; ~485 to 460 Ma). The GOBE records the staggering increase in diversity of taxa that evolved during the Cambrian Explosion and represents the single most sustained increase in marine biodiversity in Earth history.

The upper Bell Island and Wabana groups form a ca.150-m-thick succession of both clastic and chemical sedimentary rocks composed of eight distinct lithofacies that accumulated during the incipent stages of Rheic Ocean development. Lithofacies stacking patterns indicate that deposition occurred during a marine transgression with superimposed small-scale sea level fluctuations producing six parasequences. Parasequences that contain ironstone are 10 to 20-m-thick and composed of hummocky cross-stratified sandstone interbedded with organic-rich mudstone and phosphatic Fe-silicate-bearing siltstone, which is overlain by hematitic granular ironstone capped by an erosive flooding surface.

This lithofacies association is interpreted to record the deposition of upwelling-related ironstone on a storm-dominated shelf. The close association of Fe-silicates with phosphorite typical of upwelling systems suggests that Fe was delivered from deep, anoxic, nutrient-rich seawater that also stimulated high surface productivities. The result was the precipitation of authigenic carbonate fluoroapatite in anoxic organic-rich sediments that accumulated near the upwelling front. The gradual advection of Fe-rich waters away from the upwelling front initiated precipitation of Fe-silicate coated grains and cements in suboxic pore-waters. Iron pumped into shallower environments through advection and Fe-redox cycling is interpreted to have precipitated Fe(oxyhydr) oxide grains in sediment of the oxygenated middle shelf. Iron(oxyhyrd) oxide coated grains were later reworked by fairweather and storm currents on the shoreface to create granular economic Fe deposits.

Although existing theories on Phanerozoic ironstone formation rely on a continental source of Fe, this model challenges convention by proposing a mantle source that supplied Fe to the shelf through upwelling. It also highlights the potential connection between the delivery of anoxic, ferruginous seawater to the margins of the Rheic Ocean and the Early Ordovician extinctions that punctuate the beginning of the GOBE.

3D-MODELLING OF FACIES HETEROGENEITY OF A CHATTIAN CARBONATE RAMP (SALENTO, SOUTHERN ITALY)

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The aim of this work is to build a metre-scale 3D model of facies heterogeneity of the Chattian Porto Badisco Calcarenite carbonate ramp outcropping in the Salento Peninsula (southern Italy). However, in shallow-water carbonate systems, capture metre-scale facies heterogeneity into threedimensional models remains controversial due to the possibility of facies coexistence and their association can change through time and space.

Within this context, the continuous and well-exposed Chattian Porto Badisco Calcarenite carbonate ramp allows detailed study of the distribution of facies association and their architecture along the depositional profile. The facies and the depositional model of the Porto Badisco Calcarenite are referred to those defined by Pomar et al. (2014). The Porto Badisco Calcarenite is a homoclinal carbonate ramp with a euphotic inner ramp characterised by the extensive seagrass meadows, passing basinward into a large rotalid packstone and coral mounds developed in mesophotic conditions. The deeper part of the oligophotic zone is characterised by rhodolithic floatstone to rudstone and large lepidocyclinid packstone.

The methodology used in this work combines classical field data collection (measure of stratigraphic logs and facies mapping) and 3D stochastic modelling by using Petrel software (trademark of Schlumberger). All the data were georeferenced and insert into the software to build the digital outcrop model. The 3D facies model has been performed after several simulations through specific stochastic algorithms (SISim, TGSim) in order to match the depositional geometries and the facies association observed in the outcrop. The 3D modelling represents a useful tool to better understand the facies architecture and their complex heterogeneity. Moreover, a detailed 3D-facies model provides an essential tool to characterize semiquantitatively sedimentological features for subsurface reservoir studies.

EARTHQUAKE-INDUCED DEFORMATION STRUCTURES IN THE UPPER MIOCENE-PLIOCENE SEDIMENTS, DENIZLI BASIN, SW TURKEY

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In terms of seismicity, the Denizli Basin take place in a significantly active region and there are many strong earthquake evidences (up to m 7.0) in the instrumental and historic periods. In this study, paleoearthquake traces have been investigated in sediments that were deposited within the basin with the opening of Denizli Basin. The earthquake-induced deformation structures have been divided into four groups: (i) clastic dykes, (ii) water escape structures, (iii) load casts–flame structures and (iv) synsedimentary faults. Deformation structures could be resulted from uploading, storm waves, sudden changes in groundwater and seismic shaking. When field observations, regional tectonics, sedimentological data and previous studies related to the topics are evaluated, it is concluded that these deformation structures have been created by seismic shaking. Being observed widely of seismites in different horizons in the lacustrine sediments of the Denizli Basin, display that the region exposures to active tectonics from Upper Miocene up to day and the earthquakes of m ≥5 occur frequently.

SEDIMENTOLOGY AND ICHNOLOGY OF THE LATE TRIASSIC IROHALEN MUDSTONE, ARGANA VALLEY, MOROCCO

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The Late Triassic Irohalen Mudstone is 500 m in thickness and is laterally continuous in outcrop within Argana valley, Western High Atlas, Morocco. This mudstone-dominated unit rests conformably on the Agelgal sandstone and represents the upper part of the Timezgadiouine Formation. It comprises two fining-upward and coarsening-upward alluvial plain sequences that are accumulated under semi-arid climate. The two sequences are represented by (1) Lower Irohalen Mudstone and (2) Upper Irohalen Mudstone. It is composed predominantly of floodplain siliciclastic mudstones with interbedded proximal crevasse splay sandstones that evolve laterally into extensive floodplain siliciclastic mudstone, ephemeral lacustrine carbonate mudstones and distal crevasse splay siltstones. Channel sandstones and levee siltstones are also present. The lower Irohalen Mudstone has yielded a low diversity and abundant invertebrate and vertebrate ichnofossils. The invertebrate ichnofossil assemblages include *Scoyenia*, *Cruziana*, *Rusophycus*, *Taenidium* and *Fuersichnus*. The vertebrate ichnofossils consist of the lacertoide ichnogenus *Rhynchosauroides*, the dinosaurian ichnogenus *Grallator*, and the chirotherian ichnogenus *Brachychirotherium*. The purpose of this contribution is to describe the facies and associations of facies constituting the lower Irohalen Mudstone and to review these vertebrate and invertebrate ichnofossils and discuss their occurrence in a sedimentological and paleoenvironmental context.

SEDIMENTOLOGY OF BENTIU AND ARADEIBA RESERVOIR FORMATIONS, HAMRA EAST OIL FIELD MUGLAD RIFT BASIN, SUDAN

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The Muglad rift Basin is considered as the largest basin of Sudan interior Basins with NW-SE orientation which locally contains up to 13 km of Cretaceous-Tertiary continental sediments as a result of Central African Shear Zone. Moreover, Bentiu and Aradeiba are considered the main reservoir formations in most area of Muglad Basin. This study investigated the depositional environment, sandstone composition, diagenetic properties, and reservoir quality of these Middle Cretaceous strata at Hamra East Oil Field in SE Muglad Basin to construct a conceptual depositional model summarizing the probable geometries and relationships of the major sedimentary body types and properties in or-der to fully understand and assess the reservoir characteristics, controls and distribution. The study essentially used five sedimentological methods, including: facies analysis, which was based on: conventional cores analysis and description of six cores intervals taken from two wells (HE-2 and HE-8), in addition to a number of 38 core samples obtained for petrographic analysis, thin-sections and XRD as well as wire line logs and seismic section interpretation. The analysis of facies and description of conventional cores led to existence of five types of lithofacies, all of them are siliciclastic sediments: massive sand stone (Sm), fine laminating sandstone (Fl) planar crossbedding sandstone (SP), trough crossbedding sandstone (St) and massive silt and mud (Fsm). They can be interpreted as deposits of fluvial, deltaic and lacustrine environments; Thin section investigations of the core samples show that the percent of feldspar is between 4.537.5%. Whereas, the percent of quartz and the lithic fragments range between 91.3 – 54.8 % and 0.0 – 10.7 % respectively. Consequently, the sandstones of the study area are classified as arkoses and subarkoses. XRD analysis show that the dominant clay mineral over all sample was kaolinite beside little amount of calcite and chlorite.. The results obtained from thin section under OM and XRD helped to identify two type of diagenetic process, first one lead to decreasing the reservoir quality that includes: carbonate cementation, precipitation of kaolinite, compaction and quartz overgrowth while the other process which increasing the reservoir quality includes partially to completely dissolution of feldspar.

THE MIXED CARBONATE-SILICICLASTIC SYSTEM OF NÉPOUI (LOWER MIOCENE, NEW CALEDONIA): A RECORD OF POST-OBDUCTION VERTICAL MOTIONS ALONG THE WESTERN MARGIN OF NEW CALEDONIA

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Over the last century, studies investigating the post-obduction period of New Caledonia (Oligocene to Recent) have been primarily focused on the peridotite nappe, mainly because it hosts Ni-bearing ore deposits and covers a third of the area of New Caledonia's Grande Terre. However, its insular nature associated with its tropical climate favored the development of carbonate platforms during the Neogene and the Quaternary, which constitute key records of post-obduction vertical motions and past climate. Indeed, carbonate ramp systems are known since the Lower Miocene in the Népoui area and would have evolved during the Quaternary into the present day rimmed platform, with a barrier reef considered as the second largest in the world. These quaternary systems have recorded relative sea-level variations since their onset at 400 ka year and a low subsidence of the margin estimated at 0.08 $mm.yr^{-1}$.

This study focuses on the mixed carbonate-siliciclastic system cropping out on the western Caledonian margin, in the Népoui area. This ca. 200 m-thick depositional sequence firstly comprises an Aquitanian ramp that unconformably overlies Priabonian syn-obduction turbidites of the Népoui Flysch. This first aggrading carbonate ramp is overlain by a prograding fan delta reworking the erosional products of ultramafic obducted massifs. The onset of this terrigenous system marks a relative sea level fall, probably associated with an uplift of Grande Terre. The siliciclastic system evolves progressively towards a second carbonate system of Burdigalian age incised by several conglomeratic channels filled by ultrabasic clasts, interpreted as an open platform, thus forming an overall mixed transgressive uppermost succession.

More recently, a new onshore borehole (S2 well) investigated the distal part of this mixed system, and recovered 170 m of cores through the entire succession. The basal part is composed of 70 m of Aquitanian carbonates interpreted as being developed in mesophotic to oligophotic environments. These are overlain by a limited, 15 m-thick terrigenous interval comprising heterogeneous fluvial conglomerates to shoreface sandstones that evidence a high facies lateral variability and a relative low longitudinal extension of the fan delta. The overlying Burdigalian limestones in this area are extensively karstified and impregnated by red lateritic mud. This atypical facies suggest that deposits were affected by several emersion periods during the Neogene. In addition, all Burdigalian deposits of the S2 borehole are affected by a secondary dolomite that suggests the presence of a fresh to marine water mixing-zone.

This integrated study shows the specificity of the Miocene mixed platform of New Caledonia, which developed downdip of the peridotite massifs affected by a strong weathering and erosion. In addition, the development of an Aquitanian ramp of at least 100 m thick and the preservation of the Burdigalian fan delta suggest significant accommodation space creation during the Lower Miocene. This could be linked to the formation of a giant gravity-driven fold-and-thrust-belt along New Caledonia's western margin and/or to post-obduction normal faulting.

A NOT SO FLAT MERIDIONAL TEMPERATURE GRADIENT DURING THE HOT EOCENE: RECONCILING PROXY AND MODEL DATA

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The Paleogene is a period of Earth history marked by major climate change. The Early Eocene (48-56 Ma) greenhouse climate state characterized by high sea surface temperatures (SSTs) and atmospheric CO_2 levels was followed by an important cooling stage leading to the formation of the first permanent ice-sheets on Antarctica at the Eocene-Oligocene Transition (EOT), ca 34 Myr ago and to icehouse conditions. Prior to this climatic swing, during early and middle Eocene, multi-proxy studies indicate relatively steady oceanic temperatures, and overall, evidenced a latitudinal temperature gradient of surface oceanic waters flatter

than under present-day settings. Furthermore, climate model simulations struggle to reproduce such a low meridional temperature gradient even with high pCO_2 background values. In this study, we take advantage of the excellent preservation state of the coccoliths, and of recent developments in the biogeochemistry of these phytoplankton to reconstruct $\delta^{18}O$ derived SSTs analysed at various sites distributed latitudinally in the Atlantic Ocean (sites ODP 925/929, ODP 689/690, DSDP 516 and DSDP 549). Collectively, the oxygen isotope compositions of diagenetically-screened coccoliths, with suitable treatments of $\delta^{18}Osw$ and ^{18}O vital effects based on recent published literature, allow us to reconstruct a reliable evolution of the meridional temperature gradient during the Paleogene. The Paleogene long-term evolution in SSTs reveals an important global cooling from the early to middle Eocene, thus challenging previously reported steady trends. Furthermore, the data reveal that glaciation was preceded by a phase of accumulation of oceanic heat at the lower latitudes. We interpret this pattern as resulting from the entrenchment of a strong meridional temperature gradient (~25°C) 4 Ma prior to the EOT. We further posit that glaciation was fostered by the constriction of South Atlantic gyre, itself due to the development of a proto-Antarctic circumpolar current in a more progressive context of declining pCO_2. From a modelling perspective, our results match the modelled temperature gradients inferred for atmospheric CO_2 levels between 4 and 16 times greater than present-day values with an optimal model-data agreement at 8 times. This coccolith $\delta^{18}O$ derived SST reconstruction, and ongoing work to derive pCO_2 estimates from the $\delta^{18}O$ offset of size restricted coccolith assemblages, prove to be a strong approach to resolve the proxy-model discrepancy without invoking the “missing physics” in the models or having to tweak the models with extremely high CO_2, as previously suggested.

RESERVOIR QUALITY OF ORDOVICIAN SANDSTONES FROM THE ILLIZI BASIN, ALGERIA: THE ROLE OF ILLITE CEMENTS

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Mature Ordovician quartzarenites from the Illizi Basin (Algeria) contain porosity/permeability values that make these sandstones an interesting target as hydrocarbon reservoirs. The presence of several textures of illite as different diagenetic phases permits to evaluate their role as a reservoir quality control.

A set of fineto coarse-grained, poorly to well-sorted sandstones from drill-cores were analyzed. The sandstones are mainly quartzarenites with very fewK-feldspars (traces) and fine-grained rock fragments (fillites), suggesting that they were generated from intense sediment maturation processes (recycling and reworking). Sandstone framework shows strong both mechanical and chemical compaction. The diagenetic paragenesis involves illite pore-lining, bitumen, quartz overgrowth, kaolinite/dikite and fibrous illite porefillings. Minor authigenic minerals include pyrite, Fe-and Ti-oxides, siderite, calcite, ferroan-dolomite and ankerite. These quartzarenites have well-preserved intergranular primary and secondary porosity as a result of framework grain dissolution (most probably K-feldspars.

SEM inspection permits to identify two types of illite textures: (1) early coatings on detrital framework grains (flakes), resulting from an eogenetic transformation of smectites; and (2) late illite pore filling (fibers), which appear to be partially replacing illite flakes and/or kaolinite/dickite booklets. Clay coat flakes prevent nucleation of quartz cement, which was able to grow between gaps of the clay coats from adjacent grains, forming well-developed euhedral faces, engulfing illite-flakes. Fibers occur only in wide enough pore spaces, whereas tight pores do not contain fibers.

The pore network is petrographically characterized to have primary intergranular and secondary oversized, honeycomb and moldic pores, resulting from dissolution of K-feldspar grains. This fact outlines the influence of the original composition on the pore-system evolution. Capillary pressure measurements were used to characterize the pore geometry and pore-throat size distribution. In spite of good porosity values (around 8%), permeability values are low (< 0.1 mD) caused by the high S/V ratio of illite fibers within the pores. There is a clear difference between petrographic-derived porosity estimates and laboratory measurements, most probable due to the existence of microporosity within primary clay matrix, clay-rich grains, and authigenic illite and kaolinite minerals.

This study shows the impact of depositional texture, composition, and diagenetic processes on sandstone reservoir quality. The results will lead to establish better correlations of illite cement formation and porosity and permeability reduction as well as to identify potentially good quality reservoirs in undrilled areas.

CORRELATION OF BASAL CONGLOMERATES OF PALEOZOIC DEPOSITS OF WRANGEL ISLAND AND PALEOGEOGRAPHIC RECONSTRUCTIONS

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The main structural features in Chukotka fold belt are formed as a result of Early Cretaceous collision of the Siberian continentand the ArcticAlaskaChukotka microplateand closure of the South Anyui (Proto-Arctic) ocean. There are many publications about Mesozoic deposits of Chukotka, but the Paleozoic geological history is not well understood. Paleozoic rocks are the part of Chukotka Fold Belt and presented by terrigenous and carbonate sedimentary complexes. All sedimentary deposits are deformed and folding.

We are focused on basal conglomerates of Devonian and Carboniferous sedimentary complexes. We use the three objects: conglomerates from Southern (i) and Central (ii) tectonic zones of Wrangel island and conglomerates from Chukotka Peninsula (Kibera Cape, iii).

On Wrangel Island basal conglomerates documented in Devonian, Lower Mississippian and Lower Pennsylvanian levels, conglomerates from Kibera Cape are Lower Mississippian level (Tournaisian). Conglomerate unit consists of many beds (10 cm to 50 cm). Dating of conglomerates is based on fauna of overlapping strata and U-Pb data of conglomerate matrix.

(i) Devonian conglomerates of Southern zone of Wrangel Island consists of pebbles and cobbles of granites and metamorphic schists. Lower Carboniferous conglomerates of Southern zone of Wrangel Island consists of pebbles of sedimentary rocks, quartzite and quartz, in a smaller quantity are present granites and metamorphic shists and slates.

(ii) Lower Carboniferous conglomerates of Chukotka (Kibera Cape) are presents by cobbles and pebbles of two types – polymictic and oligomictic. Oligomictic conglomerates consist of granites or shists layers. Rock fragments of polymictic conglomerates are present quartz, quartzite, chert, granite, limestone and slate.

(iii) In the composition of Upper Carboniferous conglomerates of Central zone of Wrangel Island are three types. In the lower type there are cobbles and pebbles of Neoproterozoic basalts, in the middle type there are fragments of sinsedimentary and Silurian limestone and many different rocks fragments. Upper type is represented by quartzite and quartz. Devonian and Lower Carboniferous Conglomerates of Wrangel Island and Kibera Cape has been involved in Ellsmirian tectonic deformation and uplift of Neoproterozoic basement. Conglomerates depositionally overlies terrigeneous marine deposits, forming in the forefront of regressive delta in Southern margin of Wrangel Island. At Kibera Cape conglomerates formed aprons around local granite uplifts on the shelf. After pre-Pennsylvanian deformation local uplifts appeared in the shallow water zone (Wrangel Island). Conglomerates formed around the uplifts-islands. However, a long exposure of the basement led to the formation of weathering crust. Therefore, in the conglomerate composition the stable rock fragments dominate.

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MINERAL PRECIPITATES IN MODERN MICROBIAL MATS: CRYSTALLITES, SPHEROIDS, BACTERIA AND VIRUSES

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Reports of dolomite occurring within microbial mats relate precipitation to microbial activities and associated EPS (mucilage). Other minerals precipitated include calcite (low-Mg, high-Mg, very high-Mg), aragonite, Fe and Mn Ca-carbonates, Mg-silicates and pyrite. In modern high-intertidal microbial mats from Qatar, SEM-TEM analysis shows mineral precipitation beginning in the topmost layer of the mat with an amorphous Mg-Si-Ca material forming within EPS around bacteria. With time and depth of burial within the mat, this develops into Mg-silicate fibres (palygorskite) and CaMg-CO_3 crystallites. Calcite crystallites grow from a nano-point of nucleation to form conical bundles, splaying out 20-30o. Growth in two or more directions leads to dumbbell and stellate structures. Cones develop a triangular and then hexagonal shape, and eventually terminations to give nail-headtype (rhombohedral) calcite crystals, 5-30 microns in length.

Spheroidal structures are distributed within the mat and in some cases coalesce to form compound structures. There appear to be 2 sizes, nano-scale and micron-scale. The larger spheroids (0.5-2 microns, some of 'micropearl' appearance) could well be permineralised bacterial-algal cells, or intracellular precipitates. The smaller spheroids (10s-100 nm) may well be viruses, as suggested by their size, shape (icosahedral), and in being attached to coccoid bacteria. TEM observations show the nanospheres occurring within micron-sized bacterial cells as well, i.e. they are bacteriophages. Like the EPS, the virus-like particles (VLP) are also being permineralized and these could well be the seeds for the nucleation of carbonate crystals, especially VHMC and dolomite, which also occur in the mat. The source of silica for the Mg-silicates could be wind-blown dust or diatoms, and the Mg-Ca is likely from seawater. Silica dissolution-Mg silicate precipitation, and carbonate precipitation, are likely to have been driven by pH-SI-redox changes within the mat, related to micro-environmental changes induced by the microbes and their (+EPS) degradation. Indeed, with the superabundance of viruses in marine sediment pore-fluids (10 million per ml), linked to bacteria (1 million per ml), VLP could well be the catalyst for the extensive precipitation of silicate and carbonate minerals.

CARBONATES AS AN INDICATORS OF SUPERIMPOSED FLUIDAL PROCESS IN BLACK SHALE FORMATIONS

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The work is based on the study of local carbonate solids of Triassic (sections of the eastern islands of the archipelago Svalbard) and Jurassic (Bazhenov Fr. of Western Siberia) black shale formations. Location of secondary carbonates in black shale formations enriched in organic matter (OM) as a result of hydrocarbon-CO_2 fluids interaction with the host rock is natural. Firstly, it is due to the large amount of fluids generated by high-carbon sediments at different stages of lithogenesis; secondly, their origin over the zones of fluid filtration from the generation and accumulation sources is probable; in the third, it is possible their formation under the influence of high-temperature hydrothermal processes and intrusions. The analytical complex, including petrography, SEM, XRD, pyrolysis Rock-Eval, the investigations of group and molecular (GC-MS) composition of sedimentary organic matter (OM) and isotopic analysis of carbon and oxygen, allowed to distinguish genetic types of carbonate rocks; including those formed as a result of fluidization effects.

The first type of HC fluidization indicates the stadial process of OM transformation in diagenesis stage. Biochemical transformation of OM leads to significant geochemical heterogeneity and redistribution of authigenic mineral components. The formation of nodules is the consequence of this process. Their morphology, structural-textural, mineral and chemical features are determined mainly by the lithological composition and the level of thermal transformations of the host rocks.

The second type of fluidization processes is connected with the migration and redistribution of HC from the source rocks. Unlike the nodules of the first group, these carbonates have rather pure calcareous composition. OM refers to the hydrobiont or hydrobiont-bacterial type, the presence of bacterial biomarkers is confirmed, a number of hydrocarbon structures (cycloalkanes, PAHC) indicate a palaeoseeps. These limestones are characterized by the maximum light isotopic composition of carbon (negative $\delta^{13}C$ to -23.3 ‰) and relatively high crystallization temperatures calculated from $\delta^{18}C$.

The carbonate metasomatic rocks, which are often encountered on contact with the sills of dolerites of the Late Jurassic-Early Cretaceous age, are singled out as a special group. The rocks have a cryptocrystalline structure, calcareous composition with numerous authigenic sulphides. A number of biomarkers (steranes, terpans, PAHC) indicate the thermal transformation process. The values of bituminous coefficient β ($\beta = 100 \times AXJI / C_{org}$) are more than 20 (background values is 5-10), it reflects the presence of epibitumoids. Negative excursion of $\delta^{13}C$ of carbonates to -20 ‰. The temperatures of crystallization reach 120-145 °C, which is much higher than the maximum temperature of the host rocks. Lithological and geochemical features of the selected groups of carbonates suggest that their formation was the result of a complex history of development of black shale strata, and indicates both background lithogenetic transformations and superimposed processes, including high-temperature hydrothermal.

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CLAY MINERALOGY OF THE EARLY AND LATE OLIGOCENE PALEOSOLS OF THE HIMALAYAN FORELAND: IMPLICATIONS FOR INITIATION AND INTENSIFICATION OF SW MONSOON

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In this study we present detailed record of the early and late Oligocene paleosols from the Himalayan Foreland. Early Oligocene paleosols represent marine to continental transition in the Himalayan Foreland. The fossil soils are characterized by deep red colour, rhizocretions, bioturbation, illuviation, Fe/Mn mottles/ concretions, and pedogenic carbonates. Whereas in the late Oligocene part of the fluvial sequence paleosols are less frequent with dominance of channel body sediments. The paleosols from this part are characterised by yellowish brown colour, bioturbation, rhizocretions, illuviation, but little or no pedogenic carbonates. The X-Ray diffraction studies of total clay (< 2 μm) and fine clay (< 0.2 μm) shows dominance of smectite, vermiculite, chlorite, kaolinite, mica and small amount of quartz. The vermiculite shows chloritization is some of the paleosols. This is in contrast with early Oligocene paleosols which show presence of similar clay minerals excepting smectite. This suggests significant change of climatic conditions from Early Oligocene to Late Oligocene. The early Oligocene paleosols with large amount of pedogenic carbonates suggest initiation of monsoonal conditions over the Indian sub-continent that was weak. However, the paleosols from late Oligocene part of the sequence suggest increased intensity of the south-western monsoonal conditions. This is also confirmed by a relative change of ITCZ with respect to the paleogeographic position of the Indian subcontinent during Early Oligocene.

CONTROLS OF POST-OROGENIC FORELAND BASINS EVOLUTION: INTERNAL RIVER NETWORK REORGANIZATION VS EXTERNAL (CLIMATE, TECTONICS) FACTORS

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The Ebro and Duero basins in northern Spain represent two Cenozoic foreland basins, which developed adjacent to growing compressional orogens like the Pyrenees and the Cantabrian mountains to the north, the Iberian and Central Ranges to the south, and the Catalan Coastal Range to the east. They were once connected as an endorheic basin in the Early Oligocene. By the end of the Miocene, Ebro and Duero rivers individualized and became connected to the Mediterranean Sea and the Atlantic Ocean, respectively.

Although these two drainage basins recorded similar histories, they are characterized by very different morphologic features. The Ebro basin is highly excavated, whereas the original topography of the Duero basin is well preserved and may be considered as quasi-endorheic. These two adjacent basins show contrasting preservation states of their endorheic stages and represent an ideal natural laboratory to study what factors (internal / external) control drainage divide mobility, and drainage network and landscape evolution in post-orogenic basins.

To that aim, as part of the OROGEN Project, we use field-based observations and apply the Khianalysis to river profiles across the boundary between Ebro and Duero drainage basins and evaluate the spatial pattern of divide migration.

We show here that contrasting excavation of the Ebro and Duero basins drives a reorganization of their drainage network through a series of captures and resulted in the southwestward migration of their main drainage divide. Fluvial captures have strong impact on drainage areas, fluxes, and therefore on incision capacity, especially for the captured basin.

We conclude that drainage reorganization, and capture of the Duero by the Ebro, independently from tectonics and climate, promote the preservation of geomorphic features of endorheism in the Duero basin due to loss in drainage area.

RICLA MEMBER: A PROGRADING SAND-SHOAL COMPLEX INFLUENCED BY HIGH-FREQUENCY SEA-LEVEL CHANGES (KIMMERIDGIAN, IBERIAN BASIN)

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Understanding the sedimentary architecture and facies heterogeneities of well exposed Upper Jurassic carbonate sand-bodies provides valuable information for comparison with subsurface analogous significant hydrocarbon reservoirs, such as those found in the Smackover Formation in the USA Gulf Coast or the Arab-D Formation in Arabia.

The Ricla Member (Kimmeridgian, Upper Jurassic) is an outstanding mixed siliciclastic-oolitic prograding sand-shoal complex developed in the high energy areas of the inner ramp domain during a regressive context. This unit is exposed in different dip to strike-oriented sections in the Iberian Ranges (NE Spain) and has a thickness up to 22 m-thick in the most proximal outcrop area, pinching out basinward down to 5 m-thick on distal localities. The important lateral continuity of the 7 km-long exposures with nearly undeformed and uncovered clear panoramic outcrops allow the study of the facies distribution, and lateral and vertical geometries of this cross-bedded oolitic-siliciclastic succession, getting a 3D reconstruction.

The detailed analysis of the facies architecture performed here reveals a depositional model consistent in a clinoformed surface with differentiated topset, foreset and bottomset parts characterized by the occurrence of different sedimentary structures. The progradation of the sand-shoal complex was controlled by the frontal migration of straight-crest bedforms in shallow conditions, around the fair-weather wave base.

Five successive units responding to high-frequency sea-level changes have been identified fromphysical tracing along the panoramic outcrops and analysis of high-resolution photomosaics and drone-made videos. These sedimentary units are internally organized into sigmoidal-shaped sets, composed by oolites and siliciclastic detrital grains in variable proportion. The overall seaward prograding migration shifts progressively through the successive units from southwest to southeast dominant palaeocurrents. The resulting facies distribution, presence of master bedding surfaces and stacking patterns architecture of the Ricla Member prograding sand-shoal is due to the depositional mechanisms associated to high-frequency sea-level changes superimposed to the regressive context, which includes the effect of the high-stand sea-level and forced regression.

ORBITAL RHYTHMS IN GROWTH STRATA

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To disentangle the weight of climatic and tectonic signals in the geological record is a challenging issue of importance for sedimentary sequence prediction. As the astronomical theory advances new techniques both in the use of proxies and spectral analysis and statistical software are developed. This allows to extend the Astronomical Polarity Time Scale down to Cretaceous times and to create astronomical floating timescales throughout the Phanerozoic. Strong climatic signatures are documented from very especial paleoenvironments, such as pelagic marine or lacustrine systems, which are very sensitive to changes in the system conditions, and are readily shifted by orbitally-forced climate changes. Besides, there are settings considered not as suitable for recording orbital rhythms because a strong tectonic signal is believed to mask climate shifts. Nevertheless, we already showed that there are some environments considered unsuitable to preserve Milankovitch cycles where actually orbital cycles can be found, such as distal parts of foreland basins, or in small basins with margins governed by strike-slip fault systems. In this work we tested for Milankovitch cycles in growth strata. We selected the Pico del Águila, in the Southernmost thrust margin of the Pyrenees in the Jaca Basin. The anticline and related syndepositional sequence presents excellent exposure and its evolution is well studied from different approaches. We provide a new chronostratigraphic framework based on previous paleomagnetic sites together with a new magnetostratigraphic section. This is used to determine the age and duration of the sequences and to establish a robust correlation with other deltaic sequences within the south-pyrenean foreland. Astronomical tuning with the 400-kyr cycle of the eccentricity solution of the Earth orbit is attempted on the basis of the new magnetostratigraphic age constraints. These results allowed assigning the notable thickness contrast between the hinge and lateral synclines in the regressive tract as tectonically controlled. On the other hand, it is worth pointing out that we found evidence of eccentricity cycles in the aggradational stack of deltaic and mixed platform sedimentary sequences. Transgressive (regressive) trends correlate with maxima (minima) of eccentricity cycles pointing out base level changes due to shifts in eustasy as a main forcing in the sequence generation.

A REVISED CLASSIFICATION AND TERMINOLOGY FOR STACKED AND AMALGAMATED TURBIDITES IN ENVIRONMENTS DOMINATED BY (HEMI)PELAGIC SEDIMENTATION

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Stacked or amalgamated turbidites provide an opportunity to infer the synchronous triggering of multiple slope failures, which is a criterion often used to attribute these slope failures to earthquake shaking; and such turbidites are thus a proxy for reconstructing long-term earthquake recurrence. However, other processes, such as erosion, reflecting turbidity currents and seiching, may produce similar amalgamated/stacked deposits. Here we study two turbidites from Lake Challa, a crater lake on the lower slopes of Kilimanjaro (Kenya/Tanzania). The occurrence in Lake Challa of both single slope failures and basin-wide landslide events, all accompanied by distal turbidites, provides an excellent opportunity to assess the characteristics and significance of amalgamated/stacked turbidites in an enclosed lake basin with diatomaceous sediments, reflecting hemipelagic sedimentation in offshore areas. We also compare the characteristics of amalgamated/ stacked turbidites in basins other than Lake Challa to discuss potential causes of different amalgamation patterns (stacked or multi-pulsed character). The low density and elongated shape of diatom frustules increases grain-to-grain interaction and thereby damps turbulence, resulting in faster bed aggradation and a stacked character of the amalgamated turbidites. Finally, as currently both synchronously and non-synchronously triggered turbidites are in literature referred to as "stacked turbidite", we propose a revised terminology that differentiates an "amalgamated turbidite" from a "turbidite stack". In sedimentary environments that are dominated by (hemi) pelagic sedimentation, and where turbidity currents are anomalous events, an "amalgamated turbidite" can often be shown to be the result of synchronous triggering, while a "turbidite stack" must always result from a succession of discrete events.

LONG-TERM CHANGES IN ATMOSPHERIC CIRCULATION DURING THE PALAEOZOIC: SHIFTING BETWEEN A SUBTROPICAL-EVAPORITE AND A POLAR-GLACIATION DEPOSITIONAL MODE

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During the Palaeozoic Earth went through three long phases of extensive evaporite precipitation (Cambrian, Devonian and Permian). These were separated by phases of aerially-restricted evaporite formation and concurrent extensive (polar) glaciation (Ordovician/Silurian and Carboniferous/Early Permian). A data inventory shows that evaporite basins had a surface area on a scale of ~105 km^2 during phases of restricted aridity (wet phase) and ~106 km^2 during phases of extended aridity (dry phase). Transitions between those phases occurred every ~60 My, were "abrupt" and line up with major extinction events (End Cambrian, End Silurian, Late Devonian and End Permian events).

A plausible explanation for the observed long-term alternation is a fluctuation of the width of the arid, subtropical belt. We developed a simple mathematical model to estimate fluctuations of belt width, based on evaporite-basin surface area and the probability that a potential evaporite basin and its surrounding drainage area are located entirely within the dry zone. Today's situation, with a width of the dry subtropical belt of about 30 degrees (approx. between 10 and 40 degrees) likely resembles a wet phase. The model then predicts a width of ~42 degrees for dry phases. Since this widening may be partially at the expense of the equatorial tropical zone this implies a poleward shift of the "upper" boundary of the subtropical dry belt from 40 to at maximum ~50 degrees. This is in line with palaeolatitude records for evaporite basins between 0 and ~47 degrees.

The data suggest that atmospheric-circulation patterns during the Palaeozoic shifted predictably between two extremes of "small" and extended Hadley cell dimensions. Extension of Hadley cells resulted in shrinking of the midlatitude Ferrell cell and the Polar cell and their boundaries were pushed towards the poles accordingly, thereby limiting widespread polar glaciation. The Palaeozoic glacial record supports this. Following Cambrian extensive evaporite deposition, glaciogenic deposits from the Late Ordovician glaciation first appeared when the Ordovician-Silurian wet phase was ~20My underway; they peaked halfway (30 My) and continued until the end of the wet phase (65 My). Late-Palaeozoic glaciogenic deposition took off ~30 My into the Carboniferous wet phase, then intensified gradually only to peak at the end of the wet phase (~65 My). Late Palaeozoic glacial deposition continued well into the Permian dry phase, but was of limited lateral extent.

The observed alternation of dry and wet phases correlates well with tropical sea-surface temperature records. High temperatures during dry phases are consistent with intensified Hadley-cell circulation and consequently with a poleward extension of the subtropical belt. The dry/arid alternation has a stable frequency of 115/125 My and has continued since, with extensive evaporites during the Late Jurassic/Early Cretaceous (S. Atlantic, Gulf of Mexico) and during the Palaeogene/Neogene (Red Sea, Mediterranean), and therefore seems to have been the primary long-term climate driver since the beginning of the Palaeozoic. Wet phases then formed a window for widespread polar glaciation when the right conditions were met, such as sufficient continental mass in polar regions.

TOWARDS AN INTEGRATED DEPOSITIONAL MODEL FOR SALT GIANTS

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Not many basins ever reached a stage of widespread evaporate precipitation, because that requires that a basin and its drainage area are located largely or entirely within the subtropical belt. Therefore, most evaporite basins are relatively small. Even fewer basins reached a stage of halite precipitation. Remarkably basin that have are typically the larger ones.

Salt giants have long puzzled scientists and different models have been proposed to explain their formation. The giants, as well as small and medium-sized salt basins, share a number of compositional and stratigraphical characteristics. These include 1) gypsum/anhydrite along the basin margin and halite in the central basin, 2) a large-scale cyclic build-up, 3) a consistent upward thinning of cycles, and 4) a composition enriched in gypsum/anhydrite relative to sea water. Depending on the model one or more of those characteristics are incorporated. Here we present a model that explains all of the above aspects.

The basis of the model is the extremely high rate of salt precipitation and basin filling as compared to siliciclastic and carbonate basins; so fast that basin subsidence is almost entirely isostatic in nature. The thickness of sulphate-halite cycles in the undisturbed, central parts of many, if not all, salt basins decreases predictably up the sequence following the following pattern: 1 (depth of the first cycle), 1/2, 1/4, 1/8 etc. This is in line with calculations that a basin of depth X that is rapidly filled with halite (density=2.15 g/cc) causes an isostatic subsidence reaction that amounts to 50% of the original depth of the basin, thus creating accommodation space for the next cycle.

Numerical modelling has shown that the composition and 3-D architecture of individual cycles can be explained by a mechanism operating entirely within the basin and without any overriding allocyclic control. When an arid basin is connected to the open ocean by only a narrow opening (e.g. a graben), allowing inflow of ocean water but at the same time restricting out flow of brine, it may become saturated with respect to calcium sulphate. If that happens the precipitation of calcium sulphate, which typically occurs along the basin's edges (because the net effect of evaporation is higher in shallow water), causes progressive narrowing of the opening and further restriction of outflow of brine. This then leads to progressively higher salinities. Modelling results show that this is a rapidly self-accelerating process that may ultimately lead to halite precipitation. The process of obstructing the ocean corridor is much faster in larger basins because the ratio of surface area (evaporation) to basin margin (precipitation) increases with basin size, which explains the dominance of large salt basins.

Although halite basins are known from the entire Phanerozoic, salt giants were formed only during distinct phases, each lasting ~60 My (Cambrian, Devonian, Permian, Late Jurassic/Early Cretaceous, Paleogene/Neogene). Using a mathematical model we estimate that during those times the width of the subtropical, arid-climate belt may have been as high as ~42 degrees (compared to the current ~30 degrees).

A TWO-DIMENSIONAL, QUANTITATIVE APPROACH TO SEQUENCE STRATIGRAPHY AND ALLOCYCLIC DEPOSITIONAL CONTROL

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Since its introduction in the 1970s sequence stratigraphy has advanced rapidly and has become a well-established and useful method to gain detailed insight into the evolution of sedimentary basins and has proven to be a reliable tool in hydrocarbon exploration and production. Initially, the method focussed on sea-level fluctuations solely but with time it became clear that variations in sediment supply (long-term trends and cyclic fluctuations) and subsidence trends were factors to take into account. This has considerably improved the applicability of the method but unravelling the interplay of sea level, tectonics and sediment supply has proven difficult.

To quantitatively assess the role of the mechanisms at work we developed a JAVA application (SequenceModeller) that simulates the infilling of sedimentary basins in response to superimposed sealevel fluctuations, variations in sediment supply and tectonic subsidence in two dimensions for marine (shoreface) and marginal marine or continental basins (deltaic).

We present examples of model runs that show that cyclothem sequences from Pennsylvanian Euramerican coal basins, as well as shoreface sequences from the Cretaceous Western Interior Seaway (USA) have formed primarily in response to sea-level fluctuations. Furthermore it is shown that variations in sediment supply are important but do not play a major role shaping the build-up of cyclic sedimentary sequences.

SEDIMENT DEPOSITION AND PRESERVATION IN MOUTH BAR COMPLEXES OF PROGRADING DELTAS

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In deltaic environments, the largest volumes of sandy deposits occur at the delta top (as channel accretion, overbank deposits) and as distinct or amalgamated sandy mouth bars in the upper delta front. We use process based models to study the preserved sediment composition in four evolving deltas, each with a different input sediment profile. We show how the mouthbars preserve a large volume of the overall preserved sand in the sedimentary record of deltaic systems.

We go on to show how the input grain size signal is alterd in the mouth bar deposit for different input sediment profiles. The results show that mouth bar deposition amplifies the contribution of medium to very fine sand grain sizes. However, the exact grain size distribution preserved in the mouthbars superimposes strong supply signal onto the amplified grain size classes, leading to complex sediment distribution patterns.

The results have implication for the selection of modern analogues to describe ancient deposits. It highlights the challenge in comparing modern systems, which are often characterised by their sediment supply or delta top grain sizes, to ancient deposits, which are typically characterised by to their sandy delta front clinoforms. The sediment supply signal may be dampened in these delta front mouth bars. Therefore, characterising ancient deltaic environments based on supply grain size will be challenging when the majority of the available data is from the preserved mouth bar deposits.

VARIATION IN FLUVIAL DISCHARGE ON DIFFERENT TIMESCALES AND ITS EFFECT ON DELTA STRATIGRAPHY

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Deltaic depositional environments can be classified in many ways, e.g. wave and tidal processes, sediment supply, grain size and cohesivity, sediment load, changes in accommodation space etc. In addition, autogenic organisation adds complexity, where lobe switching causes local changes in sedimentation and auto-retreat can occur. While conceptual models often assume constant depositional forcing, in nature these processes and conditions are rarely constant across the timescales at which they act.

To improve understanding of the controls on delta stratigraphy it is important to consider the natural variation in these processes across different timescales. In this work we have varied the fluvial input in process-based models of deltaic deposition and studied its effect on clinoform geometry.

A reference model was created by supplying constant bank-full discharge to a sloped basin with subordinate tide and waves. The advantage of such an approach is that the high constant fluvial input simulates long time scales in a relatively short amount of calculation time. The disadvantage is that it does not incorporate the effect of periods of reduced flow. During periods of low fluvial supply the delta front is reworked by the marine processes affecting the clinoform geometry without the impedance of fluvial currents. These periods of low fluvial supply also allow fine sediments to settle on the delta which can later be preserved as mud/clay drapes.

In order to study the effect of flooding behaviour on these aspects of clinoform geometry, models were created with variations in fluvial input across three timescales. The first model simulates episodic floods followed by low flow conditions. The second model assumes input variations based on wet and dry seasons. The final two models simulate a gradual increase in fluvial discharge and a gradual decrease in fluvial discharge respectively – analogous to a change in catchment climate. The results show how the clinoforms of the same delta can evolve differently under fluvial variation on 3 different timescales. We show how process-based numerical modelling can bring us a step closer to distinguishing between event-driven to climate driven variation in deltaic deposits. In this work only one variable has been adujsted. However, this methodology opens the possibility to study the effect of a whole range of process variations, allowing us to make a better link between the processes we observe in modern systems and the preserved ancient deposits we observe in outcrop and subsurface data.

FACIES INDEPENDENT RESERVOIR CHARACTERIZATION OF A MICROPORE-DOMINATED GAS FIELD

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Micropore-dominated carbonate reservoirs remain challenging for accurate hydrocarbon evaluation and production as conventional reservoir models using depositional textures and petrophysical properties to distribute porosity and permeability cannot be applied. Nevertheless, understanding the distribution of pore systems and predicting the fluid flow behavior of microporous reservoirs is fundamental as micropores constitute a significant percentage of the total porosity and storage capacity.

We present the results from an integrated study on a producing micropore-dominated gas field characterized by a facies independent, diagenetically controlled pore system that approaches 100% microporosity. Four cored wells were described and correlated using stacking patterns and vertical facies trends; pore type characterization was done through thin section petrography, routine core analyses, scanning electron microscope and mercury-injection capillary-pressure data. In addition to core and thin section data, a 115 km^2 full-field 3D seismic survey and several hundred km of 2D seismic lines were available for regional mapping and interpretation of large scale structures. Cumulative gas production data from 120 wells were used to assess production trends.

This study is an example of a permeable reservoir in which intergrain pores are cemented during burial diagenesis and micropores, being more resistant to cementation, remain open to depths greater than 4000 m. A unique relationship exists between porosity, permeability, median pore-throat size and microcrystalline textures, independent of facies and fabrics. Cumulative gas production data show there is a correlation between the total porosity and the structural position of the wells – wells high on the structure have the highest production. We demonstrate that an equally well-connected micropore network exists in mud dominated rocks via the matrix, and via grain-to-grain contacts in grain-dominated rocks. The here described intragrain micropore network through grain-to-grain contacts in cemented grainstones is a new carbonate flow path that will likely become more important as more unconventional carbonate reservoirs are explored.

A global assessment of limestone microporosity suggests these observations are valid for microporedominated carbonate reservoirs spanning a broad range of geologic ages, depositional facies, and burial depths.

TECTONISM AND VOLCANISM FORCED BY GLACIATION AND DEGLACIATION EVENTS IN SOUTHERN ICELAND

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Central southern Iceland is one of the main outlets of the Icelandic Ice Sheet. A MIS 5e sedimentary complex, the Rangá Formation, is extensively observed and overlapped by the Late Glacial and Preboreal (Búði) terminal moraines and the Þjorsardalur lava flows. This formation yields one of the first continuous and complete estuarine records in Iceland of the Eemian Interglacial, including evidences of tectonic and seismic activities. It contains a thick tephra from Grimsvötn volcano, known in marine cores as 5e low BasIV and positioned at c.127 Ka BP. Moreover, it overflows MIS 6 tills and a Veiðivötn lava yielding c.155 Ka BP. The Rangá Formation is related to a rapid deglaciation with a proglacial lake, dammed by a forebulge, followed by two marine glacio-isostasy forced transgressions separated by a 9 Ka long regression phase. This regression signals the distal signature of a complex glacial advance within the Last Interglacial attributed to the Intra-Eemian Cooling Events (Greenland GS26 or marine events C25-C26). The analysis of this complex allows, thanks to tephrostratigraphy, a better insight of the interconnections between sea level, volcanic and tectonic activities during deglaciations or glacial building and the Northern Hemisphere marine or ice cores records. Low intensity earthquakes along volcanic swarms and the South Iceland Seismic Zone (SISZ) recurrently affected sedimentation, especially during early deglaciation stages, probably controlled by the migration of a forebulge. Rifting events and fault reactivations are mostly active during early deglaciation events. During climate optima and late interglacial or interstadials, earthquakes are much less frequent but of a higher magnitude along the SISZ, in relation with lower groundwater levels. Subglacial volcanism is related to the thickening/loading phases of the ice sheet, although eruptions generating tephra and subaerial lava flows are linked to unloading/deglaciation events, whatever the volcano, especially if the magma chamber is shallow. This sketch seems valid at least in regard to the four deglaciation events recorded in southern Iceland.

EVIDENCES OF QUATERNARY SEISMIC ACTIVITY IN THE BAY OF BREST (BRITTANY, FRANCE). TREZ-ROUZ, PEN HAT AND KERGLEUZ SECTIONS

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Brittany (France) was occupied by permafrost at least during the four last glacial periods of the Quaternary, allowing the development or the diagenesis of deformed sediments by differential frost heaving and solifluction processes. In these Quaternary deposits most evidences of tectonic activities are limited to sedimentary hydroplastic deformations. If the seismicity of a region is today well defined by decennal instrumental measurements, it is very difficult to analyse the palaeoseismicity in an intraplate region, where most of the events are limited to shallow crustal depth without superficial evidence of rupture.

These deformations, at Trez Rouz and Pen Hat (Crozon peninsula), as also in the Elorn estuary, were induced by liquefaction triggered by shallow earthquakes leading to shale diapirism. Seismically induced shale diapirism as described at Pénestin (Vilaine River esturary) seems in continental basins to be frequent, especially in non-consolidated saprolite or clayey marsh deposits, minimum 10 m thick, often associated with water-escape features in sands. Shale diapirism develops when a shallow water table is available to promote liquefaction, especially during late interglacial highstands and when potential confining layers exist. The intensity of earthquake does not seem to be very important, if higher than Mw 4. A chronological analysis extended to the West of France revealed an event close to 400 ka at the onset of MIS 10 and another at the transition between MIS8 / MIS9a, synchronic at regional scale, with a sea-level close to the present-day one. These twin events, triggered by the onset of glacio-isostatic deformations seem unique at the scale of Quaternary.

FACIES ARCHITECTURE AND STRATIGRAPHIC DEVELOPMENT OF A THIN, LOW-GRADIENT DELTA ALONG A SANDY COAST – THE CRETACEOUS MESA RICA SANDSTONE IN NEW MEXICO (USA)

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A rare case of thin, low-gradient delta architecture is documented along Albian-Cenomanian cliff sections in New Mexico, where analysis of facies distribution, depositional architecture and the spatial extent of stratigraphic surfaces reveal a characteristic pattern of laterally varying shallowingupward facies successions. The dominantly fluvial Mesa Rica Sandstone is characterized by a ~350 km NNW-SSE depositional profile from southeast Colorado to northeast New Mexico where it feeds a 15-20 m thick contemporaneous delta. The upstream fluvial strata record deposition of an extensive sandstone sheet, as documented by others. Its delta terminus has received limited attention besides micropaleontology, palynology and organic geochemistry, which has been applied to reconstruct sea level fluctuation and coastline migration.

Strike, and dip sections were constructed from observations along a 20 km$^+$ escarpment in the Tucumcari Basin, east-central New Mexico, ~60 km down-dip from the first indicators of deltaic development in the hitherto fluvial system. Five facies associations were recognized in the study area, and form the basis for this reconstruction. Moderately bioturbated prodelta mudstones grade into completely bioturbated distal sandstone bars of which the high and uniform bioturbation index suggests slow sedimentation and persistent wave agitation. The presence of thin hyperpycnal deposits in the lower part of the distal bars is evidence for occasional high river-discharge events. The strata grade further into slightly coarser grained indistinctly bedded mouth bar sandstones with a uniform and low bioturbation index. Erosive and channelized crossstratified channel sandstones (distributary or trunk) with a commonly present pebble-sized lag form the top of the upward shallowing succession. Channel-incision depth varies significantly within the study area, and is ascribed to interplay between sediment supply and base level change. The number of vertically stacked parasequences varies locally, but an inverse relationship between thickness and parasequence count results in a generally constant thickness for the whole succession. Areas with only a few or several stacked parasequences contain thicker or thinner units, respectively. Distal-to mouth bar clinothem geometries are observed in just one locality, typically reaching 120-160 m in down-dip extent. Here, the total interval thickens significantly over a short distance, possibly explained by a local depression in the paleo-basin bathymetry.

The presence of sub-regional flooding surfaces and a laterally varying number of paraseqeuences is interpreted to reflect lobe abandonment followed by local subsidence and possible later re-activation. In turn, this suggests that autogenic lobe switching accounts for flooding surfaces of limited lateral reach, whereas allogenic forcing explains widespread flooding and their associated surfaces. Accurate identification and temporal constraints on flooding events may be applied as a framework to improve facies mapping and consideration for compartmentalization in delta successions. The dimensions of the incising channels are comparable with the upstream trunk channels, indicating a further continuation of the delta in the down-dip direction, beyond outcrop exposure to the SSE. Unraveling the interplay of paleo-bathymetry, dominant processes (fluvial, wave, tidal) and slope gradients for the Mesa Rica Sandstone delta will significantly contribute to the understanding of delta development in low-gradient basins in general.

PALEO-GLOFS: ASSESSING THE IMPACT OF CLIMATE CHANGE ON THE FREQUENCY OF GLACIAL LAKE OUTBURST FLOODS I PATAGONIA

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Glacial Lake Outburst Floods (GLOFs) constitute a major threat to local communities and infrastructure in glacier-covered regions. These catastrophic events occur when a lake dammed by a glacier or moraine is suddenly emptied, resulting in abrupt flooding. This issue is particularly pronounced in Patagonia's Baker region (47–48°S), where 21 GLOFs were documented in the last decade. In the Baker area, all recent GLOFs were initiated by the emptying of Cachet 2 lake through a subglacial tunnel into the Colonia river, a tributary of the Baker river. During such GLOF events, the Baker river, which is the largest river in Chile draining most of the eastern side of the Northern Patagonian Icefield, triples in discharge and river water level rises by 4 to 6 meters. Although the frequency and magnitude of GLOFs seem to have increased worldwide in the last decades, there is currently no reliable scientific evidence supporting this claim, largely due to a lack of flood records on timescales that extend beyond gauged river-flow datasets. To examine changes in GLOF frequency in Patagonia and investigate if the apparent increase in GLOF events is related to global climate change or if it simply reflects the natural evolution of glacierized regions, sediment cores were collected in the Baker river floodplain upstream of Colonia river. Preliminary results indicate the occurrence of fine-grained organic-poor material alternating with laminated units of dark organic-rich sediment. It is hypothesized that the fine-grained material is deposited during flooding whereas the organic-rich soils represent periods of quiescence. In the near future, the cores will be dated using radiocarbon and radiogenic nuclides and the results will be compared to historical chronicles and reconstructions of glacier evolution to assess the possible relationship between GLOF frequency and climate change.

CHARACTERIZATION OF A HETEROGENEOUS SEQUENCE BOUNDARY SURFACE PERPENDICULAR TO THE PATAGONIAN FOLD-AND-THRUST BELT: THE ROLE OF FOSSIL FOREST

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The mid-Cretaceous Mata Amarilla Formation marks the onset of the foreland stage of the Austral/ Magallanes Basin (southern Patagonia Argentina), which is related to the first stage of growth of the Andes. It is composed of three informal sections which were deposited in littoral and continental environments. The boundary between the lower and middle sections of the Mata Amarilla Formation shows a drastic reduction in accommodation/sediment supply (A/S) ratio, interpreted as a sequence boundary surface. This surface is characterized by a well-developed palaeosol, associated with the extensive preservation of a podocarp-dominated fossil forest over a vast area (more than 5400 km). Sedimentological and palaeopedological analyses, in conjunction with forest structure, tree density and growth ring analyses, indicate that the mid-Cenomanian sequence boundary can be distinguished as a non-uniform regional surface developed over a short period of time. In a west-east transect perpendicular to the Patagonian fold-and-trust belt, this heterogeneous surface is delimited in the western part by an erosional surface generated by a large lateral channel migration recorded by sheetlike channel deposits with transported logs. By comparison, towards the eastern part of the study area, it appears as a paraconformity bounded by a very mature vertic Alfisol, which may have taken 40–100 ky to develop, and the preservation of a fossil forest in life position with a minimum age of 337 years. On the other hand, in a north-south transect parallel to the Patagonian fold-and-trust belt, this surface is interpreted as a forced regression surface because towards the basin depocenter overlies shallow marine deposit of the lower section of the Mata Amarilla Formation. However, this interpretation is not so clear in the west-east transect towards the basin margins where this surface overlies distal fluvial and littoral deposits of the lower section of the Mata Amarilla Formation. It is concluded that the extensive presence of these fossil forests at the same stratigraphic level in a vast region respond to changes in A/S ratio in a forced regressive surface at basin scale.

BIOGENIC SILICA DIAGENESIS AND ANOMALOUS COMPACTION IN SEDIMENTARY BASINS

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The diagenesis of biogenic opaline silica leads to dramatic petrophysical variations in the host sediment (i.e. anomalous compaction), in particular over the depth of the opal-A to opal-CT transition zones. However, although diagenetic processes associated with these changes are reasonably well understood, the kinetics of the opal-A to opal-CT process are not well represented by quantitative models. Constraining the rates and mechanisms causing anomalous compaction is therefore crucial in identifying which transitions are ongoing, or still active, versus fossilised. This, in turn, will improve our understanding of silica cycling and sedimentation through time. This study documents the physical-property changes in the Neogene biosiliceous sediments at the Ocean Drilling Program Sites 794 and 795 in the Sea of Japan, and places them in a diagenetic context to gain a process-based understanding of the physical and chemical controls on diagenesis in biogenic siliceous sediments, the anomalous compaction that results.

Physical property measurements and quantitative mineralogy show that the sharp porosity reduction during opal-A to opal-CT transformation at Sites 794 and 795 can be attributed to chemically induced sudden anomalous compaction phenomena that cause sediment framework to lose its strength, under fragmentation and extensive opal-A dissolution, allowing collapse of the sediment matrix. The subsequent precipitation of pore-filling opal-CT further decreases the porosity. Pore-water chemistry and mineralogical analyses indicate that solubility equilibrium has been reached with respect to opal-CT in the transition zones at ODP Sites 794 and 795, implying that the precipitation of opal-CT is still an ongoing process. Despite variations in pore water silica concentration and host sediment mineralogy, our data show that pore water temperature is the most crucial factor in determining the rate of opal-A to opal-CT transformation. This, in turn, opens the possibility that kinetic modelling of the opal-A to opal-CT transformation can quantitatively examine the influence of bottom water temperature and burial history on silica sedimentation and diagenesis through time

SOURCE AND SEDIMENT TRANSPORT DIRECTION OF THE UPPER JURASSICLOWER CRETACEOUS DEPOSITS (WESTERN CHUKOTKA, N-E OF RUSSIA)

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One of the most important tasks in paleogeographic reconstructions is determination of sediment transport direction. Traditionally, two main methods are used for this purpose: the palaeocurrent and the palaeoslope analysis based on the measurements of directional structures and the study of lateral facies changes. However, a number of favorable factors are needed for this investigation, such as good exposures and not intensive tectonic deformations.

The Upper Jurassic-Lower Cretaceous deposits within the Chukotka terrane are strongly deformed and rarely form extended outcrops, which makes it difficult to study them by these classical methods. Therefore, we focus on analytical laboratory techniques to collect the maximum information about source rocks (composition, age and geodynamic nature). Then, taking into account the geological structure and history of the region, we locate their sources and determine the geodynamic position of the basin. The obtained results allow to understand the direction of sediment transport.

The Upper Jurassic-Lower Cretaceous deposits uncomfortably overlie Triassic clastic sequences. Triassic turbidites deposited in a passive margin settings and show southerly direction of sediment transport (modern reference frame). Large tectonic reorganization and a break in the sedimentation in the Early-Middle Jurassic time are associated with the opening of the Amerasian basin and the separation of the continental block. The accumulation of the Upper Jurassic-Lower Cretaceous deposits on the southwestern edge of new microcontinent (Chukotka microplate) occurred under the influence of processes related to its convergence with an active margin of Siberia. The South Anyui Ocean and the Kulpolney Island Arc located between two active margins.

The Oxfordian-Kimmeridgian sequences are presented most by sandy debris flows deposits and less turbidites. Their arcosic sandstones contain small angular mudstones fragments, which are very similar to the Triassic mudstone by geochemical characteristics. Petrography and isotopic analysis also shows the domination of the Precambrian coarse crystalline rocks and subordination of the Jurassic volcanic rocks in source area.

The Tithonian formation are composed of interbedding sandstones, siltstones and mudstones with conglomeratic lenses, inferred to be submarine channel deposits. Composition of tithonian greywacke and litharinites indicate the domination of basinal clastic and volcanic rocks in source area. Geochemical characteristics and geochronological investigations of volcanic pebbles suggest presence of the Tithonian destructive plate-margin andesites and dacites in source area.

The Lower Cretaceous deposits are represented by turbidites. Composition of subarcosic sandstones indicate the Precambrian granitoids, the Triassic clastic and the Jurassic volcanic rocks in source area.

The Precambrian coarse crystalline rocks are associated with the ancient continent Arctida that located at the South, in Arctic region, and was the source area for the Triassic and the Oxfordian-Kimmeridgian basins on Chukotka. At theTithonian time direction of sediment transport were changed to northerly as a result of the accretion of the Kulpolney Island Arc to the southwestern edge of Chukotka microplate. The Tithonian volcanic rocks became the main source. The Lower Cretaceous deposits continued to accumulate due to erosion the Jurassic volcanic complex and recycling of the Triassic and The Oxfordian-Kimmeridgian clastic rocks.

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SUPER BOUNDING SURFACE DEVELOPMENT IN A FLUVIAL-AEOLIAN INTERACTION SYSTEM: TOWARDS A MODEL FOR FLOOD-GENERATED "STOKES' SURFACES"

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Super bounding surfaces are key elements for understanding the long-term evolution of aeolian systems and represent major changes in aeolian sediment budget triggered by extra-erg factors. Multiple parallel-truncation bedding planes (aka Stokes' surfaces) have been widely described for ancient aeolian systems, associated with changes in the sediment budget and deflation to water table; although deflationis not a requisite and non-climbing, migrating ergs can also develop parallel-truncation planes. Deflationary or non-climbing conditions have been usually related to sustained dry conditions and exhaustion of the original sand supply. However, episodes of fluvial flooding may have major impact in the sedimentary budget of fluvially-sourced aeolian systems by increasing the amount of coarse-grained supply and/or rising the water table.

The Lower Cretaceous Avilé Member in central Neuquén basin is here analysed in order to describe and interpret complex super bounding surfaces developed in an extra-erg/erg-margin/erg-centre, downwind transect. The Avilé Member is dominated by the cyclic alternation of fluvial and aeolian deposits in a ~30 m-thick, overall wetting upwards succession.

Detailed work was carried out in 16 outcrop localities in which standard sedimentary logging was carried out. Gamma Ray surveys of logged sections were also performed in order to have a comparison element with subsurface information. Architectural panels of the unit were constructed and main architectural elements defined, together with key stratigraphic surfaces (flood, deflation, sand-drift surfaces). Lateral tracking of individual surfaces between localities was performed, aided by oblique aerial photographs. The study was completed with the analysis of the Avilé Member in 5 subsurface localities in which general attributes of the unit were defined by well log suites and core description.

Five different scenarios were defined from purely wet (fluvial) to purely dry (aeolian) record. In fluvial (extra-erg) settings, the record of the Avilé Member is exclusively composed of amalgamated fluvial channel units. In the outer fringe of the fluvial-aeolian interaction zone, aeolian dune units are erosionally truncated by sandy fluvial channels, covered again by dune deposits across sand-drift surfaces. In the inner portions of the erg-margin, sandy fluvial deposits are replaced by muddy and heterolithic deposits related to unconfined floods. Yet, these deposits cover dune units across planar, horizontal surfaces that suggest episodes of deflation/bypass prior to the flooding of the system. Drier scenarios are characterized, in turn, by aeolian sand sheet units intercalated between dune deposits and bounded by horizontal sharp surfaces. These indicate deflation/bypass followed by aeolian accumulation strongly influenced by the water table. Finally, the aeolian end (erg-centre) is dominated by dune units bounded by sharp planar surfaces (Stokes' surfaces) with no evidence of moisture or water in the accumulation surface.

Tracking of these surfaces over more than 60 km suggests a close relationship between flood events in the upwind sector of the system and deflation episodes in the erg centre. The identification of the processes behind the development of these surfaces are here applied in order to build a process-response approach to the development of large-scale discontinuities in fluvial/aeolian successions alternative to classical models for deflation/bypass surface development.

THE STRATIGRAPHIC INCOMPLETENESS OF SUBMARINE CHANNELS DEPOSITS

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Turbidity currents transport prodigious quantities of sediment across the world's oceans through submarine channels, deposit major oil and gas reservoirs within submarine fans and damage strategically important seafloor infrastructure. We therefore need to understand these flows, but their very powerful nature makes direct monitoring challenging. Most studies to date focus on the deposits that turbidity currents leave behind in the sedimentological record. However, deposits of individual flow are likely to be reworked, particularly in the proximal part of submarine channels where supercritical flows dominate. This leaves us with the questions: How complete is the stratigraphy of these deposits? Are some events better preserved than others? Quantifying stratigraphic completeness, and how it varies over different temporal and spatial scales, is crucial to understand how well deposits can be used in quantifying turbidite frequency, identifying the best locations for reconstructing palaeoenvironments, and to unravel past sediment budgets.

We address these questions by re-analysing the most detailed time-lapse mapping yet of a submarine turbidity current system. This field dataset comes from the fjord-head Squamish Delta in British Columbia, Canada where Hughes Clarke (2016) collected 93 near-daily repeat surveys in 2011. These surveys revealed the seafloor response to more than 100 turbidity currents. Three channels are identified (northern, central and southern) that initiate from a delta-lip and extend to depositional lobes at approximately 150 m water depth. Thus, a highly active system can be studied from source to lobe in a compact area.

Here we use temporal changes in seabed elevation to understand patterns of deposition and erosion (and thus deposit stratigraphy) at each point during these 100 successive flows. We calculate the total thickness of sediment deposited at each location, and the percentage of this sediment that is preserved (the stratigraphic completeness). Erosion by subsequent flows may substantially reduce stratigraphic completeness, and the majority of initial deposits are reworked by later flows. The average stratigraphic completeness near to the three channels is < 1%, but this is highly spatially variable, as some levees record up to 40% completeness. This low value is largely due to upstream migrating bedforms that constantly rework previously emplaced sediments. Three different patterns are found in the three channels. The northern channel shows a disproportionate preservation (up to 60%) of limited run-out, but large delta-lip failures in its upper course (due to their plugging effect, which drive minor avulsions). The central channel is mainly erosional in its proximal part, and has little preservation of deposits in the lower channel. The southern channel is dominated by erosion, with net-erosion due to meander bend incision, and at the channel lobe transition zone. Perhaps surprisingly, even at the terminal lobes, stratigraphic completeness is typically < 5%; especially close to the channel mouths. These results provide new insights into the evolution of submarine channels and why their deposits produce a highly incomplete record of submarine flows.

THE LACUSTRINE MICROBIAL CARBONATE PRODUCTION OF THE SUCCESSIVE BONNEVILLE AND GREAT SALT LAKES, UTAH, USA

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The Bonneville Basin is a continental lacustrine system accommodating extensive microbial carbonate deposits corresponding to two distinct phases: the deep Lake Bonneville (30,000 11,500 ^{14}C BP) and the shallow Great Salt Lake. A detailed characterization of these microbial deposits and their associated sediments provides insights into their spatio-temporal distribution pattern during both lacustrine phases. The Bonneville phase displays a preferentially vertical distribution of the microbial deposits resulting from highamplitude lake level variations at that time. Due to the basin physiography, the microbial deposits were restricted to only a narrow shoreline belt. Carbonate production was more efficient during intervals of relative lake level stability as recorded by the formation of successive terraces. Our survey revealed a new terrace from the poorly documented early history of Lake Bonneville. In contrast, the Great Salt Lake microbial deposits showed a preferentially large lateral distribution, linked to the modern flat bottom configuration of the Bonneville Basin. The low vertical distribution is the combined result of a shallow water depth and low amplitude lake-level fluctuations. During this phase, the microbial deposits display a higher diversity of fabrics and sizes. They are distributed along a shore-to-lake transect on a flat platform in relation to local and progressive changes in the accommodation space. Microbial deposits are discontinuous throughout the lake history showing longer hiati during the Bonneville Lake phase. The main parameters controlling the rate of carbonate production are related to the interaction of physical (kinetics of the mineral precipitation, lake water temperature, runoff), chemical (Ca^{2+}, Mg^{2+} and HCO^{-} concentrations, Mg/Ca ratio, dilution, depletion) and biological (trophic) factors. The evolution of Lake Bonneville and Great Salt Lake microbial deposits is discussed in terms of major chemical, physiographic and climatic changes during this interval. Furthermore, it provides novel insights into the formation of fossil microbialites under freshwater and hypersaline conditions.

RE-ANALYSIS OF LEGACY DATA FOR QUANTITATIVE PROVENANCE STUDIES: HEAVY-MINERAL ASSEMBLAGES OF THE MIOCENE NORTH SEA BASIN

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As a direct result of the recent proliferation of quantitative data-acquisition techniques, coupled with progress in data processing and modelling approaches, a new field of study aimed at solving the fundamental problem of reconstructing mass transfer from source areas to sedimentary basins has begun to emerge. Quantitative sedimentary provenance studies play a central role in the development of mass-balanced geological reconstructions of sediment fluxes. Due to modern technological advances, many types of quantitative bulk and single grain analyses are available. These advanced methods are often, however, expensive and applied on limited amounts of material.

In the 20th century many classic heavy mineral data were collected. These data were, however, mostly used as qualitative indications for stratigraphy and provenance, and not further incorporated in a quantitative provenance methodology. This is also the case for the southernmost edge of the Miocene North Sea Basin in Belgium and the Netherlands. In this research, legacy data are used to come up with a conceptual model of the paleogeographic evolution and changes in sediment input at the southern edge of the North Sea Basin. First, a compilation of literature data provides information on all lithostratigraphical units present, their characteristics, geographical extent and biostratigraphical age. Second, heavy mineral data can be collected from available (both published and unpublished) databases. Statistical analysis of these large databases provides an objective means to recognize different groups in the data and to determine which minerals mostly affect these groups. These groups can then be linked to both regional and temporal changes in sediment input. Finally, a conceptual model of the paleogeographic evolution can be built based on a combination of all collected data.

A pitfall of these old databases is the lack of good time and depth information, which limits the resolution and accuracy of the conceptual model. Also, often the lack of grain size information means that variations in mineral content due to grain size variations cannot be taken into account. In the next phase of this research, new compositional data – heavy mineral data and chemical data – will be combined with grain size data and dinoflagellate cyst data in order to account for hydraulic effects on the composition and to add a good temporal framework to the model. Finally, all collected data can be combined in a forward stratigraphical modelling approach in order to test the validity of the model.

THE DURABILITY OF DETRITAL GRAIN-COATING CLAYS AND THE IMPLICATIONS FOR RESERVOIR QUALITY

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Anomalously high porosity in deeply buried, clastic hydrocarbon reservoirs is often attributed to authigenic grain-coating clays, predominantly chlorite, preventing the formation of quartz overgrowths around detrital quartz grains. Well-known examples of these highly porous reservoirs are present on the Norwegian continental shelf. These authigenic, porosity-preserving, grain-coating clays are typically interpreted to develop from early detrital, pre-cursor clay coatings. However, the durability of the detrital grain-coating clays during sediment transport and early compaction is still poorly understood. This is especially important because the degree of detrital grain-coating clay coverage could be negatively affected by both transport and compaction. This in turn could control the extent of authigenic grain-coating clay formation at burial depths greater than 2 kilometres and thus influence porosity preserving potential of these clays within the reservoir. Innovative experimental analyses were used to study modern sediment containing grain-coating clays from the Ravenglass Estuary (Lake District, UK). The aims of these experiments were to: 1) investigate the stability of grain-coating clays during sediment transport and compaction, 2) study the changes in coverage and microstructural character of the clay coatings, and 3) increase understanding of the impact of detrital grain-coating clays on reservoir quality. Samples with varying degrees of clay coating were taken from four localities within the Ravenglass Estuary. Flume tank experiments were carried out to study the effect of sediment transport on the clay coatings and uniaxial compression tests were designed to study their stability during early burial. Subsequent analysis consisted of standard and backscatter microscopy and SEMEDS analysis on samples taken during the experiments to study textural and microstructural changes of the clays. The results of these experiments will be used to make predictions about the durability of the detrital graincoating clays and will increase understanding of their role in the formation of diagenetic grain-coating clays and their overall impact on sandstone reservoir quality.

PHENOTYPIC PLASTICITY OF FRAME-BUILDING COLD-WATER CORAL COLONIES: A FIRST MODELLING ATTEMPT

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The shape of frame-building cold-water coral (CWC) colonies is extremely variable both between different species and within the same species. Intraspecific morphological variations may be due to genetic differentiations (polymorphism) or to environmental influences within the coral lifetime (phenotypic plasticity). Studies on polymorphism and phenotypic plasticity are extremely important for a better understanding of the susceptibility and resilience of CWC bioconstructions to environmental stress. Nevertheless, papers in this field are almost entirely lacking.

Thanks to the recent increased attention by the scientific community towards CWC bioconstructions, a large amount of seafloor ROV videos, coral samples and oceanographic data are currently available to carry out detailed studies on coral morphologies and their relations to environmental conditions. In particular, it has been noted that the two most widespread species, Lophelia pertusa and Madrepora oculata, show highly variable growth forms ranging from hemispherical bushes to uniplanar fans mostly due to the influence of hydrodynamic factors.

This project is a synthesis on the colonial shape variations of the most common CWC frame-building species. It draws on numerous N Atlantic and Mediterranean occurrences, linked to the accompanying environmental data (e.g., bathymetry, geomorphology, hydrodynamics etc). At the same time it introduces experiments in the virtualization of CWC growth forms in preparation for more advanced modelling of their interactions with environmental factors.

THE ONSET AND EVOLUTION OF THE MIOCENE PHOSPHATIC HARDGROUND OF SALENTO (S ITALY) UNLOCKED BY ITS CORAL-MOLLUSC FOSSIL ARCHIVE

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From the late Oligocene to the late Miocene, the central Mediterranean area was interested by an extensive deposition of phosphate-rich sediments. They are usually represented by 10-20 cm thick, subhorizontal hardgrounds, made of phosphatic sediments arranged into thin layers separated by erosion surfaces. Macrofossils are very abundant, their association composed of colonial and solitary corals, molluscs, echinoderms, brachiopods, bryozoans and fish teeth. This study represents the first thorough investigation of the Mediterranean phosphorites biotic assemblage, aimed to collect new information on the environmental factors controlling their deposition. In particular, the Serravallian / Tortonian phosphatic deposits of the Salento Peninsula (named "*Aturia* level") have been selected for the abundance of fossil remains. Special attention has been given to the coral and mollusc associations, particularly sensitive to changes in the main environmental stressors and representing the most abundant biotic components.

Microstratigraphic and microfacies analyses of the Salento "Aturia level" allow to identify two distinct facies. A coral rudstone, about 7-10 cm thick, constitutes the base of the hardground and includes most of the macrofossils, while on the top lies a detrital rudstone, made of the succession of thinner layers mainly composed of phosphatic fragments.

The coral assemblage is composed of at least 16 azooxanthellate taxa belonging to 4 families, represented in order of abundance by Dendrophylliidae, Caryophylliidae, Flabellidae, Micrabaciidae. With the exception of two colonial forms, with one rather common (*Dendrophyllia* cf. *cornigera*), all identified corals are solitary scleractinians.

The mollusc assemblage is composed by a rich gastropod fauna (27 species), associated with bivalves (18 species) and cephalopods (2 species). Some of the most representative taxa are *Conilithes antidiluvianus, Bursa ranelloides, Coralliophaga lithophagella, Neopycnodonte cochlear, Asperarca nodulosa, Chama gryphoides, Glossus humanus, Venus nux, Aturia aturi.*

Three distinct depositional phases have been recognized with the basal coral rudstone actually representing the key-facies to reconstruct the onset of the "Aturia level" and the original environment of its rich fossil content.

Although time-averaging biased, the composition of the coral and mollusc association has been reliably compared with present-day analog taxa suggesting the occurrence of a heterogeneous seafloor formed by rocky substrates interspersed by accumulations of soft sediment, at few hundreds meters of depth and under the influence of moderate to strong bottom currents rich in nutrients and resuspended decayed organic matter.

CORAL REEFS AND CENOZOIC WARMING EVENTS: CASE STUDIES FROM LOWER EOCENE (N. ITALY) AND MIDDLE MIOCENE (TURKEY)

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The evolution of Cenozoic coral reefs is a complex history, with the interplay of climatic, oceanographic and biogeographic changes strongly controlling their composition, structure, frame-building capacity and depositional setting. From a palaeoclimatic perspective, within the Eocene-to-Miocene global transition from a Greenhouse to an Icehouse Earth, we present here the comparison of two case studies of coral reefs that developed during global warming phases: 1) the Ypresian Monte Postale coralgal reef (Veneto, northern Italy), that developed near the end of the Early Eocene Climatic Optimum (EECO); and 2) the lower Langhian Dağpazari coral reef (Mut Basin, southern Turkey), that grew in coincidence with the Middle Miocene Climatic Optimum (MMCO), the most recent warm phase in the Earth history. A precise chronostratigraphic calibration has been performed through the integration of larger foraminifera and calcareous nannofossil zonations for the Monte Postale and by $^{87}Sr/^{86}Sr$ isotope analyses for the Dağpazari coral reef.

For each of these examples, several, cardinal features have been considered and compared, including size and shape of the bioconstructions, coral diversity, coral cover, secondary reef-building associations, dwelling organisms and sediment textures. In both these settings the reef-building coral communities present a relatively high diversity, with at least 17 genera in the Ypresian Monte Postale and at least 15 in the Langhian Dağpazari reef. Corals are able to build a bioconstructed framework, with colonies in close contact, associated, especially during the Ypresian, to calcareous algae. Both these reefs present a margin that elevates from the surrounding sea floor, but characterized by relatively thin frameworks, reaching a maximum of 4 m in the Ypresian Monte Postale and up to 13 m in the Langhian Dağpazari reef. Data from the associated organisms indicate for these reef structures extremely shallow water conditions. Sediments within the Monte Postale coralgal reef are rich in Alveolina, miliolids and dasycladacean algae, while in Dağpazari, the abundance of miliolids is coupled by clear evidences of seagrasses colonizations. Sediment textures from the two reef structures vary from grainstones to packstones for the bioclastic deposits, while secondary reef-building organisms (mainly coralline algae and encrusting foraminifera) are usually arranged into compact, laminar bindstones, thus confirming the occurrence of high-energy, shallow-water depositional settings.

The data here presented indicate that in proximity to some of the warmest stages of the Cenozoic, reef-building corals, were able to form bioconstructed frameworks in association to variable amounts of calcareous algae. These structures were characterized by relatively small thickness and grew within the shallower part of the photic zone.

GLENDONITE FORMATION IN THE EARLY CRETACEOUS OF SPITSBERGEN – EVIDENCE FOR COLD CLIMATES AND METHANE SEEPAGE ?

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Glendonites are pseudomorphs after the mineral ikaite, and have been found in marine sediments throughout geological time. Ikaite is a metastable, hydrated form of calcium carbonate, which is only stable under specific conditions: between 0 and 8° C, and with high alkalinity and phosphate concentrations. Glendonites are often associated with cold climates due to the strong temperature control on ikaite growth, and the coincidence in the geological record with episodes of global cooling. Glendonites are found in the Lower Cretaceous succession in Spitsbergen. During the Early Cretaceous, Spitsbergen was at a palaeolatitude of ~60N, and was part of a shallow epicontinental sea that formed during the Mesozoic as Atlantic rifting propagated northwards. Though the Early Cretaceous was generally characterised by greenhouse climate conditions, episodic cold snaps occurred during the Valanginian (the “Weissert Event”) and during AptianAlbian. Using high resolution carbon-isotope stratigraphy, we show that the first occurrences of glendonites are in the upper Lower Hauterivian and in the very upper Upper Hauterivian, stratigraphically higher than the Valanginian cooling event. Glendonites are also found in horizons in the Upper Aptian, coincident with the Aptian-Albian cold snap. Petrological analysis of the glendonite structure reveals differences between the Hauterivian and Aptian glendonites, with evidence for multiple diagenetic phases of growth in the Hauterivian glendonites, suggesting oscillating chemical conditions. This evidence suggests that local environmental conditions may have a stronger control on glendonite formation and preservation than global climate. We present a new model for ikaite growth and slow transformation to glendonite in marine sediments, which points to a more complex suite of diagenetic transformations than previously modelled. We evaluate whether such pseudomorphs after marine sedimentary ikaite may be indicators of past cold water conditions and critically assess whether they reliably track methane seepage in these polar seas based on evidence from combined sedimentological, stratigraphic, petrological and geochemical techniques.

LARGE-SCALE PROGRADING OOLITIC GEOMETRIES IN THE MIDDLE JURASSIC "OOLITHE BLANCHE" FORMATION (PARIS BASIN, FRANCE): NEW INSIGHTS ABOUT THEIR PALAEOENVIRONMENTAL INTERPRETATION

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The Middle Jurassic Bathonian "Oolithe Blanche" Formation is outcropping in the eastern part of the Paris Basin, where the constitutive facies are actively exploited in large quarries. In the upper part of the Formation, large-scale prograding geometries composed of well-sorted fine to medium ooid and oobioclastic grainstone are observed, in the quarries of Massangis and Ravières-Longchant (not visible anymore in the later) separated by less than 25 km in the North of Burgundy. There, some stacked sigmoidal sets with basal tangential downlaps develop other a thickness of 10 to 15 m, possibly corresponding to more than 20 m-thick object prior to compaction, with sometimes truncations on top.

These large-scale geometries were initially interpreted as platform margin progradations in the 1980's, only on the basis of local field observations. More recently, in the frame of a renewed interest considering the "Oolithe Blanche" Formation as a potential target for CO_2 storage, they were interpreted as 3D lobes of flood deltas or large washovers, cutting through shallow shoals separating shallow tidal-dominated domains from open marine zones. However, again, this interpretation is based on local facies analysis and correlations at the quarry scale and between these quarries.

A reappraisal of the observations performed and published is proposed, and completed with newly acquired data, allowing to integrate these outcrops in a larger stratigraphic framework at the scale of the Bathonian Burgundy platform. Sequence stratigraphic correlations constrained by biostratigraphy, show that these large-scale geometries may better be interpreted as giant submarine sandwaves, forming on relatively deep banks developing during a phase of generalized although limited drowning of the entire Bathonian platform, Some similar objects, although of smaller scale, are forming simultaneously on the southern margin of the platform more than 100 km to the South.

Similar giant sandwaves are reported in recent/present day clastic and carbonated settings, and may be considered as good analogues to better constrain the depositional model(s) of the upper part of the "Oolithe Blanche" Formation.

COMPARISON OF LATE CRETACEOUS FLUVIAL SYSTEMS ALONG STRIKE THE PYRENEAN-PROVENÇAL DOMAIN FOR RECONSTRUCTING DRAINAGE AND EARLY PYRENEAN TOPOGRAPHY

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The early phase of the Pyrenees building during the latest Cretaceous is not yet well constrainedneither by geological or geophysical data or geodynamics models, particularly in the Pyrenean-Provençal domain. During the latest Cretaceous, there is evidence that the onset of shortening due to plate kinematics is diachronous along strike. Shortening started first in Provence and eastern Pyrenees during Santonian times, before migrating to the Western Pyrenees and the Bay of Biscay. The main compressive event affecting the whole chain is Early Eocene while finally the opening of the Gulf of Lion during the Oligocene ends the orogeny in the eastern Pyrenean-Provençal domain. This event masked a large part of the architectural and structural relationships between the different basins from east to west, and the geometry of the Pyrenean Axial Zone south of Provence towards the Alpine domain is unknown.

During the early stage of orogeny, the Campano-Maastrichtian fluvio-lacustrine sediments were deposited in basins along-strike from Provence (in the easternmost area) to Corbières and Ariège, to the west (in the Central Pyrenean domain). The relationships between basins and their fluvial networks are not known although the understanding of drainage systems around these early reliefs is a crucial point to unravel the path of erosional products from source to basin and hence to detect areas of uplift. Indeed, the location of the early topographies sourcing the Upper Cretaceous rivers are is known, but sedimentary basins have preserved information concerning these missing terranes.

Several Campano-Maastrichtian fluvio-lacustrine successions located in various basins of the Pyrenean-Provençal domain were studied from east to west: in Provence, Languedoc, and Corbières. A sedimentary analysis, together with a petrographic study was conducted. In particular, the reconstruction and comparison of fluvial architecture allows the recognition of variations in fluvial systems and the location of the main fluvial pathways along-strike in the proto-Pyrenees. Preliminary petrographic analysis was carried out in order to have a better understanding of the source areas and potentially pinpoint the location of early exhumation. From this dataset, it is possible to have a better comprehension of the physiography of the early Pyrenean reliefs and their location along the protochain.

CARBON, OXYGEN AND STRONTIUM ISOTOPES FINGERPRINTS OF HYDROCARBON-RICH FLUID IN MARINE SEDIMENTS AUTHIGENIC CARBONATE FORMATION: INFERENCES FOR THE PLUMBING SYSTEM

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Hydrocarbon-enriched fluids could lead to the precipitation of authigenic carbonates in modern and ancient marine sedimentary basins worldwide; particularly, but not exclusively, in compressive tectonic regimes at convergent margins. Their formation processes are still under debate, together with their different morphologies, their relations with the hosting sediments architecture and the migration pathways of associated deep fluid. Hydrocarbons and connate waters still seeping nowadays are believed to be the primary sources for the formation of fossil authigenic carbonate found in Plio-Pleistocene marine sedimentary succession along the Northern Apennines foothills. Have been considered four selected outcrops presenting dolomitic authigenic carbonate bodies hosted within the Argille Azzurre Succession and exposed by fluvial erosion, documented in three different locations along the foothills: Enza River field, Stirone River field and Secchia River field. Five different morphologies were observed among the sites: chimneys, slabs, concretions, globular concretions and irregular cemented bodies. A total of 73 carbonate samples have been investigated to understand their formation processes in relationwith observed morphologies, deep fluids migration and hosting sediment architecture. Subsampling allowed to have a detailed micro characterization with petrography, SEM-EDX observation, XRD and XRF analyses. ^{13}C, ^{18}O, $^{87/86}Sr$ have been measured on selected subsamples together with connate waters and hydrocarbons samples coming from different presentday seepages and drilled wells associated to the outcrops. ^{13}C values defined two main groups: samples with negative signatures and samples showing positive signatures; ^{18}O and $^{87/86}Sr$ point out the contribution of connate waters during their formation. Different carbon sources and precipitation processes are identified, including: 1) AOM-SR of mixed thermogenic/biogenic methane anaerobically oxidized in different reservoirs, 2) chemical precipitation associated with heavy Carbon from CO_2 derived by secondary methanogenesis. The isotopic variability recorded both among the various outcrops and within a single site, testifies that the authigenic carbonates represent a record of varying biogeochemical cycles active during the formation, and also that the final isotopic signatures recorded are linked to the possible pathways, given by the plumbing system, and hosting sediments architecture. The observed different morphologies are linked to the tectono-stratigraphic history of the study sites. Indeed, their formation varies also together with the tectonic deformation and variation in sediment supply and basin bathymetry. The multidisciplinary approach contributes in highlighting the fluid escape pathways and authigenic carbonate formation processes.

ORIGIN AND SPATIAL DISTRIBUTION OF SAND GRAIN COATS IN SHALLOW MARINE CLASTIC DEPOSITS: INSIGHTS FROM A MODERN ESTUARINE RESERVOIR ANALOGUE (GIRONDE ESTUARY, FRANCE)

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The development of clay (mainly chlorite) coatings around detrital quartz can be a major factor controlling reservoir quality in deeply buried sandstone reservoirs (> 3500 m). These coatings prevent quartz overgrowth and thus preserve porosity and permeability during burial. Although the link between clay coatings and good porosity has been established in a number of ancient estuarine sandstone reservoirs (e.g. North Sea, Bonaparte Basin...), questions remain about their initiation (sedimentary, diagenetic), the factors controlling their evolution and the prediction of their spatial distribution. Answering these questions would reduce the uncertainty associated with the exploration of such reservoirs, for deep hydrocarbons or geothermal purposes. The objective of the scientific project CLAYCOATing in shallow marine clastic deposits to improve reservoir quality prediction" is to establish the origin, nature, and spatiotemporal distribution of clay precursors in a well-constrained stratigraphic and sedimentary framework. The first phase of this project is the study a modern mud-rich estuary characterized by the presence of a Turbidity Maximum Zone (TMZ, few tens of $g.l^{-1}$), the Gironde estuary (SW France). All tidal bars, point bars and mid-channel bars have been sampled (surface sampling) from the Bay-line to the estuary mouth along a 150 km long transect, during low and high-river stage. Surface sands have been sampled in trenches during low-tide slack-water, less than 6 hours after the deposition of sandy ebb dunes. In addition, 9 boreholes were drilled with a total recovery of 50 m in order to assess the evolution of vertical facies associations. Within studied sands bars, fine fraction (< 2 m) is not negligible and accounts for 16 wt. % of the sediment on average. This fine fraction is composed of quartz, carbonate, muds and clays. The clay mineral associations are made of kaolinite, chlorite, illite and smectite. Optical and scanning electron microscopy show the existence of anisopachous sand grain coats, composed mainly of illite, smectite, a mix of smectite and chlorite or illite and chlorite, associated with diatoms, silt-size grains, and coccolithophorids. Coats are partially developed on most grains (10-30 % of sand grains surface) forming ridged, bridged, drapes or clumped textures, and rarely continuous clay drapes. In surface samples, twenty-eight percent of detrital grains are coated, on average, along the estuary. Sand grain coats are mainly located in heterolithic tidal bars from the Gironde inner estuary funnel (25 % of sand grains are coated on average) and in estuarine heterolithic point bars from estuarine channels (34 %). Lowest percentage is located downstream in the Gironde outer estuary funnel (8.5 %). Distribution of sand grain coats fits quite well with the position of the TMZ, where most of the suspended clay flocculate. The TMZ is centered on the estuarine channel during low-river stage and on the Gironde estuary funnel during high-river stage. The presence of diatoms within clay envelopes indicates a possible role of Extracellular Polymeric Substances (EPS) possibly produced by diatoms in the aggregation of clay minerals around quartz. Sand coats may also be derived from infiltration of turbid water within sand-dominated sediment.

THE INTEGRATED OUTCROP / BEHIND OUTCROP CHARACTERIZATION OF SANDSTONE GEOBODIES AND THEIR UTILITY FOR UPSTREAM INDUSTRY TRAINING

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With the aim of obtaining a solid database to build robust numerical models of sandstone geobodies, the Sedimentary Reservoirs Workgroup of the University of Granada, Spain (SEDREGROUP, www.sedregroup.com), developed a workflow based on the comparison between outcrop and subsurface data, at diverse scales, in analogues of hydrocarbon reservoirs (O/BO characterization).

This workflow is developed in the following phases (1) Selection of examples and elaboration of Virtual Outcrop Models (VOM) by photogrammetry in images obtained with Unmanned Aerial Vehicle (UAV); the chosen outcrops must comply with accessibility conditions, present sections in different directions of the space and be located in an orography that allows their posterior drilling; (2) Facies and architectural element analyses on outcrop aimed at characterizing the sandstone geobody in terms of sedimentary processes; (3) Selection of characteristic reservoir units in the geobody to be drilled; these units constitute homogeneous sets delimited by petrophysical heterogeneities within the geobody and usually correspond to specific sub-environments characterized by their petrophysics and facies associations (4) Drilling of wells with continuous core recovery; a sufficiently dense wells network is designed in order to have a core of all identified sub-environments (reservoir units) as well as the main heterogeneities that may imply permeability baffles and barriers; (5) Obtaining well logs (Natural and Spectral Gamma Ray as well as Optical and Acoustic Televiewers, ALT Systems) (6) Photo scanning of cores with the Smartcube CIS 1000L, in order to obtain in 2D a high-resolution image of the 360° of the surface of the core (view unrolled) (7) Scanning of the cores with a multisensory core logger (GEOTEK MSCL System) to obtain data from Gamma Density, P-wave velocity, Electrical Resistivity and Magnetic Susceptibility loop; (8) Obtaining slab section of cores and preparation on a metal tray for visual inspection (9) Core description and interpretation of the corresponding borehole logs; (10) Performance of Ground Penetrating Radar (GPR) profiles behind the outcrop; antennas of 200 and 400 Mhz are used to determine the three-dimensionality of the architectural elements identified in outcrop as well as to select the georadar facies corresponding to bedforms; the GPR lines must necessarily contain all boreholes in order to obtain a high precision correlation (11) Characterization in thin section of the composition and diagenetic history of the sediments; (12) Analysis of spatial distribution pattern of petrophysical properties (porosity and permeability) and heterogeneity; (13) Reservoir Quality Assessment; (12) Numerical modeling of facies and petrophysics.

This workflow is being applied in training courses for upstream industry geoscientists with excellent results when planning the Enhanced Oil Recovery (EOR) in fluvial, delta and tidal sandstone reservoirs.

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EDIACARAN SEDIMENTS OF SIBERIAN PLATFORM: VOROGOVKA GROUP

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The Vorogovka Group is a complex of marine carbonate-terrigenous deposits with a thickness of about 3,500 m, preserved in narrow graben-synclinal structure in the north-west of the Yenisei Ridge. Stratigraphic position of the Vorogovka Group is still one of the controversial issues of Late Precambrian Geology of the Siberian platform. According to the ideas of different authors, the time of its formation varies from Riphean to Ediacaran. To address this issue, we carried out the study of carbonate of the Vorogovka Group by the methods of Sr and C chemostratigraphy, and U-Pb isotope dating of detrital zircons from the sandstones of the basal horizons of the Severnaya Rechka, Mutnina, Sukhaya Rechka formations included in its composition.

Features of the composition and structure the Vorogovka Group reflect the consistent evolution of the basin from the environments to the alluvial plain of the sea shelf. Terrigenous sedimentation is replaced by carbonate sedimentation, features which control both downward tectonic movements, and periodic changes in sea level.

LA ICP-MS U-Pb-dating isotope detrital zircon of Severnaya Rechka Formation found that the youngest population of zircon (5 grains) has a weighted average age of 584±3 Ma. This suggests that the accumulation of the Vorogovka Group deposits started no earlier than ~585 million years ago, that is, in the Ediacaran.

Analysis of geochemical data made it possible to select samples of limestones from the Severnaya Rechka and Sukhaya Rechka formations with a minimum content of terrigenous impurity, subjected to minor secondary changes and retaining the original isotopic composition, and therefore suitable for isotope-chemostratigraphic studies. It was found that limestone of both formations have almost identical Srisotopic characteristics. The Sr isotope composition of Sukhaya Rechka limestones varies from 0.70816 to 0.70828. Limestone of Sukhaya Rechka Formation characterized by very consistent $^{87}Sr/^{86}Sr$ ratios ranging from 0.70813 to 0.70823. The values of ^{13}C in the limestones of these formations are somewhat different: for Severnaya Rechka limestones, value of ^{13}C is 0 (-0.7‰ to + 0.1‰), and limestones of the Sukhaya Rechka Formation have small positive values of ^{13}C (1.2‰ to 1.8‰). Variations in Sr- and C-isotopic composition observed in limestone of the Vorogovka Group are comparable to those observed in the rocks of the second half Ediacaran. For example, similar characteristics are carbonate rocks Doushantuo Formation of South China and Khorbusuonka Group of Olenek uplift in Arctic Siberia. From this it follows that the least altered samples of the carbonate rocks of the Vorogovka Group recorded the Sr- and C-isotopic composition of the waters of the Ediacaran paleoocean. This does not contradict the data of U-Pb-isotopic dating of detrital zircons from sandstones at the base of the Severnaya Rechka Formation basal unit of Vorogovka Group.

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CARBONATE PRECIPITATION IN AN ANOXIC WORLD: SULFUR AND ARSENIC CYCLING IN MICROBIAL MATS BUILDING MICROBIALITES

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Microbialites, the lithified counterpart of microbial mats, represent the earliest evidence of life on Earth, dating back approximately 3.7 billion years. The Earth's atmosphere did not become oxygenated until approximately 1.3 billion years later. Therefore, early life on Earth had to utilize oxygen independent metabolisms. The interaction of these metabolisms with mineral precipitation needs to be explored. The biogeochemistry of sulfur and arsenic cycling has been widely studied in modern microbial mats as well as in sediments, and a potential role for both sulfur and arsenic metabolisms in the Precambrian has been proposed. This paper demonstrates how specific sulfur and arsenic metabolisms may affect carbonate precipitation. Furthermore, it explores cation binding by EPS, focusing on calcium and magnesium. In microbial mats of the Atacama desert in Chile, sulfur and arsenic cycling are coupled to calcium carbonate precipitation. Photosynthesis in these permanently anoxic mat systems is supported by sulfide and arsenite, and major respiration pathways are based on sulfate and arsenate reduction. Synchrotron-based X-ray absorption spectroscopy in these mats show co-existence of As(III) and As(V) (Sancho-Tomas et al., this session). Calculations show that arsenic and sulfur cycling both have the potential to support extensive microbialite formation (i.e., calcium carbonate precipitation). These results are supported by a previous investigation using Synchrotron-based XRF fluorescence that found evidence for arsenic cycling in 2.7 Ga stromatolites (Tumbiana formation, Pilbara). This suggests that, in the absence of oxygen, prolific stromatolite development can be supported by arsenic and sulfur cycling.

LONG-PERIOD ASTRONOMICAL FORCING ON WESTERLY-DRIVEN MOISTURE TRANSPORT TO CENTRAL ASIA DURING THE MIDDLE MIOCENE CLIMATE TRANSITION

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A 450-m-thick succession of lacustrine deposits, exposed in the Aktau section in the Ili Basin, SE Kazakhstan, is representative for a phase of widespread lake formation in western Central Asia. The succession is of mid-Miocene age and covers the interval between 15.5 Ma and 10.0 Ma based on an integrated approach of magnetostratigraphy, U/Pb dating of carbonates and cyclostratigraphy. Results of our cyclostratigraphy developed from changes in facies and lake level show a strong sensitivity of sedimentary facies to moisture availability under arid to semi-arid climate conditions.

Our results suggest a control of low-frequency modulation of obliquity and eccentricity on sedimentary facies, salinity and lake level of Lake Aktau. In particular, the development of precipitation-sensitive marker beds and lithofacies changes likely correspond to the 1.1 Myr obliquity cycle. These modulations affected the development of atmospheric pressure gradients and westerly wind intensity which in turn was crucial for the magnitude of moisture transport evaporated from the Eastern Paratethys and Mediterranean seas. Here we present a stable oxygen isotope record from the Aktau succession which documents a stepwise increase of aridity across the Middle Miocene climate transition paced by maxima of three successive 405 kyr eccentricity cycles.

The minimum in the low-frequency modulation of obliquity at 14.3 Ma is equivalent to strongest cryosphere growth after the Middle Miocene climatic optimum. At these times cooler temperatures and stronger atmospheric pressure gradients promoted intensified westerly wind activity and elevated atmospheric moisture transport capacity to the interior of Central Asia. The sedimentary response in the Aktau succession is the first-time establishment of an alkaline lake with subsequent drying and gypsum formation during the Miocene. Later on, aridity increased documented by two large and sudden increases in oxygen isotopes, a 6 ‰ shift at 14.1 Ma and 4 ‰ shift at 13.75 Ma respectively. Between 13.75 Ma and 13.55 Ma, the repeated wetting and drying of saline lakes with the formation of gypsum and anhydrite represents a period of maximum evaporation and aridity in Central Asia. Furthermore, the carbon isotope record, strongly influenced by regional evaporation-precipitation processes, documents the CM6 carbon isotope excursion in a terrestrial archive. The period of maximum evaporation and aridity likely corresponds to seasonally enhanced changes in net evaporation in the Central Mediterranean Sea and the establishment of a dry-wet climate oscillation system evident from high-amplitude planktic oxygen isotope variability. On longer tectonic time scales, the occurrence of Miocene lakes in Central Asia coincides with the closure of the Eastern Gateway between the Indian Ocean and the Mediterranean Sea when enhanced salinity and evaporation in the Mediterranean and Eastern Paratethys seas likely served as main moisture source for Central Asia.

NEW INSIGHTS INTO THE ENVIRONMENTAL SETTINGS OF AN EARLY PLEISTOCENE LACUSTRINE SEQUENCE (1.7-1.9 MA) IN SOUTHERN ISRAEL

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The Saharo-Arabian desert belt has experienced significant environmental and climatic changes throughout the Pleistocene, fluctuating between semi-arid to hyper arid. These variations are evidenced by the presence of wide spread deposits that indicate pluvial intervals (as expressed by lacustrine and wetland deposits, alluvial fans, paleosols, and speleothems) or hyper-arid periods (deserts and ergs). One of these pluvial intervals is represented by an Early Pleistocene lacustrine sequence that occupied an area of 300 km^2 in the present extremely arid southern Negev desert, Israel. The sedimentary record indicates that the hydrological balance during that time was favorable for supporting a perennial and relatively deep lake.

Several studies were previously carried out on this sedimentary sequence, with the aim of reconstructing the paleoenvironmental settings, mainly through methodological investigation of the microfauna assemblages. These previous studies show that the lacustrine sequence consists of chalky limestone with some banks of massive limestone alternating with marly to sandy-marly beds rich in gastropods, ostracods, fish remains, and charophytes. The fossil assemblage indicates a freshwater to hypersaline environment with salinity ranging between 0.5‰ and 70‰. Based on archeological artifacts corresponding to the Acheulean culture found on a nearby alluvial terrace, the top of the lacustrine sequence was assigned with a Lower Paleolithic age (2.6-1.7 Ma).

The current study present new results that expand our knowledge on the chronology and enviro mental settings of Lake Kuntilla. Paleomagnetic measurements show a lower, normal polarity zone and a reverse interval in the upper part of the section. Considering previous exposure ages between 1.6 and 1.9 Ma measured on the pavement at the top of the columnar section, we correlate the observed polarity pattern with the top of Olduvai and the lowermost part of chron C1r. Hence, the Kuntilla lacustrine sequence can be dated to approximately 1.7-1.9 Ma.

New analysis of the biological diversity show that the sequence mainly contains very few species of ostracods, mostly recrystallized steinkerns of the euryhaline *Cyprideis torosa* and few shells of *Ilyocypris* (which is typical for freshwater and running water) or *Candona* (freshwater environments). The sieve residues mostly contain small foraminifera shells, probably indicating erosion of the ancient surrounding Cretaceous rocks and transported to the lake by fluvial activity. The current study is further complemented by elemental analysis of the lithological sequence (μXRF), and allows to better understand the environmental settings prevailing in the region during the Early Pleistocene and to propose several mechanisms for the expansion of humid conditions at these latitudes.

HOLOCENE ENVIRONMENTAL RECONSTRUCTIONS FROM SOUTH OF THE SAHARA: INSIGHTS FROM LAKE CHAD

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The Lake Chad basin (LCB) is an intracratonic basin dating from the Phanerozoic located in central Africa, at the northernmost boundary of the semi-arid Sahel belt and south of the Sahara desert. The LCB is one of the largest endorheic basins in the world, with a theoretical hydrologic basin surface of 2,500,000 km^2. Lake Chad lies in the path of the seasonal migration of the Inter-Tropical Convergence Zone (ITCZ), which makes it as ideally situated to study summer monsoon variability in West Africa through time. While over 80% of the water input to the lake comes from the Chari-Logone River system that drains waters from the tropical Savannah in the south, the remaining 20% of water input enters from direct rainfall on this hydrologic basin and from the Komadougou Yobe River system from the west. The water outputs from this endorheic basin is mainly through evaporation (95%) and the remaining water (5%) is loss through lake-floor seepage.

LBC can be divided into two sub-basins: while the present-day Lake Chad is only 3 m water depth occupying the southern sub-basin, a northern sub-basin is nowadays dry but filled up during the past by water during strong rainy seasons. These sub basins are linked by a hyper-arid Bahr el Ghazal valley with an elevation of 285 m above mean sea level (AMSL). Yet the two basins where connected in the middle-Holocene humid period forming the Lake Mega-Chad that covered over 350.000 km^2, an area 25 times larger than today with a maximum depth of 170 m. Indeed, despite previous studies, little is known about the timing and amplitude of the lake level fluctuations. So far, the estimation of its maximum extension only offers a static view of the early and mid-Holocene Lake Chad, while centennial lake level variations have also been highlighted.

The current study shows results from a high resolution geophysical survey complemented by coring on Lake Chad during a field campaign in December 2011. The results show that the sedimentary infilling of the lake can be divided into five internal seismic units identified by their distinctive different seismic facies. Petrophysical and sedimentological measurements carried out on the cores allow the calibration of the different seismic units into chronologically confined lithological units. Furthermore, the results show important fluctuations during the Holocene, since the Mega-Chad Lake and throughout the receding interval into the current conditions.

COASTAL SEDIMENTARY RESPONSE TO DYNAMIC NATURAL AND ANTHROPOGENIC CONDITIONS: EXAMPLES FROM SOUTHWEST FRANCE AND SOUTHEAST U.S

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Coastlines around the world are environmentally and economically important, providing critical habitat and property for recreation, resources and occupation. However, there is widespread concern about the potential impacts of rising seas and stronger storms. Coastal areas where marine forcings (e.g., waves, tides) are more intense and sediment supply is reduced or manipulated by man can be expected to demonstrate the greatest dynamics. The southwest coast of France and southeast U.S. are both exposed to the open Atlantic Ocean and an onslaught of potential sediment-shifting events. Simultaneously, humans continue to change the coastal system for varied reasons. Here examples of recent coastal evolution are provided to illustrate how anthropogenic action (or in-action) coupled with episodic storm events can govern the response. More specifically, analysis of time-series aerial photography along with field observations and core information document changes and testify to the processes shaping the coast. Insights indicate that "laissez-faire" management may be an effective approach to enhancing sedimentation and preserving habitats in some areas. For example, the breakdown of barriers (e.g., dunes or dykes) can enable overwash or estuarine flows to divert sediment for accretion and possibly mitigate impacts elsewhere.

SIMULATION AND 3D RECONSTRUCTION OF SANDSTONE INJECTITES

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The Pearl River Mouth Basin is located in the northern part of the South China Sea. It is the extension of the Southern China continent to the sea. It is a Cenozoic passive continental margin basin formed in the extensional setting. Natural gas hydrate reservoir and the reservoir mainly developed in the accretionary wedge of the active continental margin and continental slope and slope favorable tectonic environment. The development of the Pearl River Mouth Basin sandstone injectites of tectonic deformation can be used as the favorable reservoir, to a positive effect on oil and gas, also can assist fault vertical migration to oil and gas, and can cause oil and gas emission. Through the analysis of the experiment in Pearl River Mouth Basin sandstone injectites of tectonic deformation are studied deeply, which plays an important role in the exploration of oil and gas resources. This study aimed to improve the experimental scheme of Ross (2011), and use this scheme to carry on the experiment. At the end of the experiment, a set of modeling methods of frozen slice, photograph, image preprocessing, graphic gridding and voxel based model are proposed. The model reconstruction is realized and 3D visualization is realized. The deposition device is mainly composed of 16 components. This one is more convenient and simple than the prior device, and can be repeatedly tested. The experiments were conducted in 8 groups, and the influence of three parameters, including caprock thickness, inlet pipe structure and topography gradient, was investigated. After each round of experiments, the results were frozen, sliced, photographed, and multiple pictures were arranged. The horizontal and vertical coordinates of each image correspond to the X axis and the Z axis of the three-dimensional coordinate system, each slice corresponds to a Y value. Then the gridding is processed, and each two-dimensional photograph is arranged together to obtain a threedimensional reference system. Then the Image J software is used to process the image and extract the deformation pattern of the sandstone injectits. Add the result to the Petrel software, set up the virtual well, then assign the attribute body, and get the result of 3D reconstruction. For the threedimensional reconstruction results obtained from each experiment, statistical calculation of various deformation phenomena is carried out, and a geological knowledge base is established. we identified 3 types and 5 kinds of invasion, type I is invasive pipe, and can be subdivided into V pipe, 1/2 communication V pipe, 1/3 communication V pipe; type II as fluidizing zone, type III for bedrock. In order to calculate the proportion of these phenomena in each slice, the calculation formulas of each type are defined: S V pipe=0.5xaxh, 1/2 communication V pipe =0.25xaxh, 1/3 communication V pipe=0.17xaxh, Fluidizing zone=0.7xaxh S Bedrock=xaxh In the horizontal direction, the average influence range of sand volcano is 1%, and the maximum is 5.58%. In vertical direction, the average influence range of sand volcano is 7.72%, and the maximum is 29.59%.

A COMPARISON IN COLD-WATER CORAL OCCURRENCE AND CORAL MOUND DEVELOPMENT SINCE THE LAST DEGLACIATION BETWEEN TWO CORAL PROVINCES IN THE SOUTHEASTERN ALBORAN SEA

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The comparison of past cold-water coral (CWC) occurrence and coral mound development between two different mound provinces in the southeastern Alboran Sea, namely the East and West Melilla Coldwater Coral Provinces (EMCP, WMCP), reveals some striking similarities and also some discrepancies since the Late Pleistocene. In both provinces, CWCs experienced a pronounced proliferation between 14 ka BP and 8 ka BP, which was associated with high coral mound aggradation rates between 410.71 and 685.80 cm kyr^{-1} during the Bølling-Allerød and the Early Holocene. However, within this period reduced mound aggradation is documented for the Younger Dryas. The periods of enhanced coral mound aggradation coincide with a decreasing trend in the benthic foraminifera $\delta^{13}C$ values that probably reflect a gradual change in the water column structure in the Alboran Sea, when the dominant water mass at the level of coral mound tops changed from an intermediate water mass to a deep water mass (in comparison to the present-day regional $\delta^{13}C$ DIC depth profile). This long lasting trend associated with significant fluctuations points to an extended period of enhanced interactions between the involved water masses most likely resulting in a strengthened hydrodynamic setting as commonly observed along water mass boundaries. Stronger hydrodynamics enhance the important lateral food supply to the CWC, which is supported by high export productivity as reflected by high benthic foraminifera accumulation rates. However, the coral mound tops have been bathed in the deep water mass since ~ 8 ka BP, as reflected by low benthic foraminifera $\delta^{13}C$ values. The reduced coral mound aggradation in this period indicates a deteriorated setting. In addition, computed tomography results exhibit a distinct change in the coral community in the WMCP at ~8.4 ka BP. The coral assemblage changed from a Lophelia pertusa-dominated lower section (mainly accompanied by Desmophyllum dianthus) to a Madrepora oculata-dominated upper section (mainly accompanied by Dendrophyllia sp.). Overall, our data clearly point to a main role of the water column structure in influencing CWC proliferation and mound formation as well as CWC assemblage composition. The main difference in CWC proliferation between the two provinces occurred since 5 kyr BP, when CWCs seem to have vanished in the WMCP, while sparse CWCs continuously occurred in the EMCP (even until today).

CONTROLS ON THE SOURCE ROCK DEVELOPMENT DURING CENOMANIAN-TURONIAN OCEANIC ANOXIC EVENT IN MOROCCO

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The Cenomanian-Turonian oceanic anoxic event (OAE2) is a significant global event that has been linked to the widespread deposition of black shale globally. Late Cenomanian-Early Turonian (C/T) intervals have been extensively studied, however, there is still debate on the mechanisms that enhance organic matter (OM) concentration and its relation to the OAE2. Organic-rich black shales, with major hydrocarbon source potential, were widely deposited in Atlantic coastline basins (Agadir and Tarfaya basins) and Tethys influenced basins (Errachidia basin) in Morocco during the C/T interval. Detailed sedimentological, palaeontological, mineralogical and geochemical analyses of those basins were carried out to reconstruct the palaeoenvironments of source rock deposition and further investigate the driving factors for development of source rock quality in these basins.

Biostratigraphic analysis, primarily using ammonites and planktonic foraminifera, integrated with $\delta^{13}C$ analysis, have been used to resurrect a dated framework and regional correlation. These data show that all three studied basins were influenced by the OAE2, recorded by positive $\delta^{13}C$ excursion, and the data suggest the OAE2 interval in these Moroccan basins took place in the Upper Cenomanian.

During the OAE2 interval, organic-rich black shale was only developed in deep marine environments. Black shales (with TOC up to 10%) were developed in the Tarfaya Basin within a deep marine environment, while only organic-poor (TOC< 1%) shales were deposited in the Agadir Basin with no shale deposition in Errachidia Basin, both latter basins dominated by shallow marine deposition in these shallow marine basins, the paleoproductivity and redox sensitive elements are only slightly increased suggesting a lower productivity and oxic to dysoxic water conditions during this interval. Moreover, a strong dilution of detrital influx occurred in the Agadir basin suggested by a high Al content (10 wt. %).

In contrast to the Upper Turonian strata, organic-rich black shales (TOC values 5%-15%) were widely distributed in all the studied Moroccan basins during the Early Turonian. Deposition is interpreted to record the Early Turonian maximum sea level transgression. In the Errachidia Basin, for example, trace and major elements data in Lower Turonian black shale show a considerable increase in paleoproductivity sensitive elements (Ba, P, Zn and Cd) and redox sensitive elements (V, Mo, Ni, Co, U). Moreover, the black shales units yielded sparse planktonic foraminifera species, with the low oxygen tolerant Heterohelix more- mani being the dominant species. These suggest the high productivity and anoxic water conditions facilitated organic-rich black shales deposition in Moroccan basin during the Early-Turonian, but was not be a consequence of the later OAE2 event.

This intergrated study suggest a more complex control on the timing and distribution of organic enrichment and source rock deposition in Moroccan basins than the commonly held asumption that organic rich black shales developed during the OAE2 interval globally. These new results offer improved resolution and understanding on the response of shallow marine and deep marine setting to OAE2, as well as local tectonics and global oceanographic perturbations influences on source rock enrichment.

THE RELATIONSHIP BETWEEN THE SAND BODY CONFIGURATION OF THE ULTRA-DEEP TIGHT SANDSTONE RESERVOIR AND THE STABLE PRODUCTION OF GAS WELLS IN THE LOWER CRETACEOUS, KESHEN GAS FIELD TARIM BASIN, CHINA

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The Tarim Basin is a significant petroliferous basin in the west of China. The Lower Cretaceous Bashijiqike Formation whose buried depth exceeds 7000 m and has a low matrix porosity (< 10%) and permeability (< 0.05 mD), is the main gas producing interval in Keshen Gas Field of Tarim Basin. The quality of matrix pore throat of reservoir determines the stability of the production of gas field. According to CT scanning quantitative analysis, CLSM (Confocal laser scanning microscope), scanning electron microscopy, cathodoluminescence microscope, high pressure mercury intrusion and electron probe microscopy, five types of typical sandbody logging phases were developed (box-shaped, gear boxshaped, bell-shaped, fingershaped, funnel-shaped), which are spatially overlapped and migrated. From the view of core evidences, the physical property and pore throat configuration of the low resistivity reservoir are better and controlled by burial diagenesis and tectonic movement. Also, the low resistivity reservoir, whose proportion mainly from the box-shaped sand and the gear box-shaped sand is higher, become the basis of the sustained and stable gas production. On the plane, the composition of the rock in each well area is controlled by the sedimentary background and the position of the facies zone. According to that, there are more muddy gravels in the Ke hen 5 block, and the heterogeneity of the pore throat is stronger, besides, from Keshen 6 block to Keshen 9 block, the clay content is increased with the distance from source, but it is mostly in the form of interstitial substance, and the pore throat of reservoir there is relatively homogeneous. However, the difference of burial history and tectonic evolution is the main reason of diagenesis difference in different well blocks. The diagenetic effect of the near-provenance, coarse-grained and multi-mudstone strata in Keshen 5 block is greater. While the depth of 8 blocks, although far from the material source, the rock particle size is smaller, because of the high proportion of low resistance reservoir from the box type, still has the better stable production foundation. At the same time, the proportion of the low resistivity reservoirs is related to the pressure drop speed, and its' spatial distribution is a useful reference for testing perforation and stable gas production.

UTILIZING IMAGE LOGS FOR SEDIMENTARY CHARACTERIZATION IN A BRAIDED DELTA

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The Upper Triassic Xujiahe Formation is one of the main gas-producing strata in the Sichuan Basin, Southwest China. Numerous natural gas pools such as the Zhongba, Pingluoba, Jiulongchang, Guang'an, Hechuan, and Anyue gas field, which are encountered in the Xujiahe Formation, have been discovered in the Sichuan Basin. Significant exploration achievements have revealed bright prospects for the gas exploration of the Xujiahe Formation gas pools in the Sichuan Basin. However, the understanding of the lithofacies associations and reservoir architectures is commonly limited due to the limited amount and quality of data. The challenge is to recognize small-scale sedimentary structures and to interpret these in terms of microfacies types, such as distributary channel, etc. In order to aid the future natural gas production of the Xujiahe Formation, a detailed sedimentological study is needed to provide insight into the stacking patterns of the sandstone bodies. To establish borehole image interpretation guidelines, the interpretations of sedimentary textures and lithology from cores and outcrops are calibrated with borehole images and conventional logs. Lithologies in the Xujiahe Formation include conglomerates, fine to medium-grained sandstones, siltstones, mudstones and coals. Sedimentary structures in terms of bedding, scour surface and stacking style of beds are interpreted from the image and open-hole logs. Depositional microfacies are defined on the basis of grain size and sediment texture, sedimentary structures, thickness, basal and upper contacts derived from core observations, openhole logs and image logs. The Xujiahe Formation sandstones in Central Sichuan Basin are deposited in a braided delta front, of which the depositional microfacies consist of underwater distributary channel, river mouth bar, distal bar or sand sheet and underwater interdistributary bay. The depositional microfacies is predicted in a single well using a combination of openhole conventional logs, borehole images, and cores. The distributary channels, which show box-shaped or bell-shaped GR log character, are generally infilled with fine to medium-grained sandstone with massive, tabular, wedge-shaped or trough-cross-laminated bedding. Repeated fining-upwards cycles, as well as the stacked nature of individual bedsets and the presence of scour surfaces represent multistory, amalgamated, channel-fill deposits. The underwater distributary channel deposits can also be overlain by interdistributary bay mudstones, known as channel abandonment. Mouth-bar deposits, which are characterized by coarsening- up successions, infill the channels as they migrate laterally, and sometimes could be overlain by a channel deposit. The methodology has potential application to other braided delta front reservoirs with appropriate calibration and scaling.

CHARACTERISTICS OF ELEMENT ABUNDANCE AND PALEOENVIRONMENTAL EVOLUTION OF SOURCE ROCKS OF THE LOWER PERMIAN FENGCHENG FORMATION IN MAHU SAG, JUNGGAR BASIN, NW CHINA

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The study area, Mahu sag, is a negative tectonic unit in the central depression of the Junggar Basin and is adjacent to northwestern faults. The sedimentary facies of the Fengcheng Formation include fan-delta, shore-shallow lake and deep lake formed in the transition of the post-rifting and foreland. The Fengcheng Formation is one of the most important source rocks in the Junggar Basin with the complex lithology co posed of carbonate, clastic rocks, pyroclastic rocks, etc.

In previous studies, the source rock of the Fencheng Formation was considered as an unit to study the whole sedimentary environment. Researchers, however, did not take the inner heterogeneity into account or study environmental changes and its impacts on the abundance of organic matter further. This paper takes the FN No. 1 well located in the central part of Mahu sag as the research object and measures the type and abundance of elements by portable X-ray fluoreseenee detector combining the method of the whole rock analysis, X-ray diffraction. Then, paleoenvironmental evolution of the Permian Fengcheng Formation and its relationship with organic matter abundance are discussed.

The results show that, during the depositional stage of the lacustrine carbonate source rocks of the Permian Fengcheng Formation in this basin, the lake level changes frequently and paleoclimate alternates from wet to dry repeatedly. The overall salinity measured by Couch formula is high indicating an anaerobic saline sedimentary environment. Also, it reveals that the target formation is formed in reducing lacustrine environment from the enriching of LREE, depleting of HREE, weakly depleting of Ce, as well as the high ratio of V/(V+Ni). More specifically, we divide three distinctive sedimentary cycles (F1-F3, from the beginning to the end of the Fengcheng Formation) and 5 sub-cycles in the target formation by the correlation between element abundance and paleoenvironment. The water changes from fresh to low salinity at the early stage of F1 with the deposition of lime mudstones generally. From F1 to F2, the water becomes shallow with carbonate distributed mainly. The precipitation sequence of carbonate minerals is calcite firstly, then dolomite, Na-carbonate finally revealing the gradual evaporation of the lake. The TOC of source rocks with calcite precipitated is considerably higher than that of source rocks with dolomite precipitated. Then, the lake level rose, the salinity became lower after F2 characterized by the disappearing of Na-carbonate. The paleoclimate is dry and hot of the Lower Permian Fengcheng Formation according to the high ratio of Mg/Sr and Mg/Ca especially in the late stage of F2 which matches the changes of water level and salinity perfectly. Parameters like Mg/Ca, Sr/Ba are closely related with TOC indicating the depositional environment controls the enrichment and preservation of the organic matter.

DEVELOPMENT FEATURES AND PETROLEUM SIGNIFICANCE OF ALKALINE LAKES: A CASE STUDY OF EARLY PERMIAN FENGCHENG FORMATION IN MAHU SAG, JUNGGAR BASIN, NW CHINA

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Evaporites, as one important type of sedimentary rocks in geologic history, has great significance in economic values and environment identification. Among them, alkaline evaporite minerals are closely related to source rocks. Little research, however, has been done in alkaline evaporite minerals, especially in China, it started just several years ago. The Early Permian Fengcheng Formation in Mahu Sag is taken as an example to study alkaline lithofacies and sedimentary environment by core description, thin section observation, SEM, X-ray diffraction, TOC measurement, inclusion temperature test, geochemical analysis, et al. This paper discussed the development background, paleoenvironmental evolution, quality and distribution of source rocks of Fengcheng Formation combining the research of global alkaline lakes and got these: (1) alkaline lakes form in hydrologically closed basins characterized by the dominance of volcanic terrains that produce alkaline dilute inflow, usually the climate is arid-subarid here. The Fengcheng Formation is such an example that deposits sedimentation with Na-carbonate. Lithology here includes pyroclastic rock, dolomite, Na-carbonate, oil shale, reedmergnerite, etc., reedmergmerite is distributed almost everywhere indicating the presence of hot springs. (2) three distinctive sedimentary cycles (F1-F3, from the beginning to the end) of the Fengcheng Formation are identified by the correlation between element abundance and paleoenvironment which indicate transgression, regression and transgression of the lake level, the salinity and minerals in F2 show the lake is alkaline during this period. (3) the formation of alkaline lake of the Fengcheng Formation could be divided into three steps: the concentration of Mg^{2+}, Ca^{2+}, Na^{+}; the precipitation of $CaCO_3$, $CaMg(CO_3)_2$ and the reduction of SO_4^{2-} ; the precipitation of Na-carbonate. (4) the most favorable source rocks in the Fengcheng Formation are developed in F1 overlain by alkaline deposition of F2, the TOC of source rocks with calcite precipitated is considerably higher than that of source rocks with dolomite precipitated. There are more alkaline continental petroliferous basins in China, like Biyang Sag and Mahu Sag.

Thus, studying development conditions, lithofacies, organic materials formation and distribution of alkaline lake deeply can provide new ideals for petroleum exploration of continental basins.

THE IDENTIFICATION OF SEDIMENTARY ENVIRONMENTS DEPENDS ON ORGANIC AND INORGANIC METHODS

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The Leshan-Longnvsi Bulge of the Sichuan Basin in southwestern China is unique because of Weiyuan and Anyue enormous gas field in old Cambrian and Proterozoic marine strata. There are four sets of possible source rocks in the study area, from bottom to top including the lower Sinian Doushantuo mudstone, the mudstone of the third member of the Sinian Dengying Formation, and the lower Cambrian Maidiping and Qiongzhusi mudstone and shale. The present TOC value of the four sets of source rocks are different, the lower Cambrian including Maidiping and Qiongzhusi formation are rank best.

Sedimentary environment is an important condition affecting the quality of source rocks. Based on the organic (Pr/Ph, Pr/n-C17, Ph/n-C18, Ga/17α,21βC30hopance) and the inorganic geochemistry methods (V/(V+Ni), V/(V+Cr), Ni/Co), we evaluate the sedimentary environment difference between Maidiping, Qiongzhusi and Dengying Formation.

The plot of pristane/n-C17 vs phytane/n-C18 of the four sets of source rocks suggests marine organic matter as the source for the kerogen, and all the source rocks were deposited under anoxic conditions. But through the plot of pristane/phytane vs gammacerane/17α,21βC30hopance, we can find the difference. The mean ratio of pristane to phytane and gammacerane to 17α,21βC30hopance of the third member of Dengying Formation is 0.53, 0.19 respectively, but the mean ratio of pristane to phytane and gammacerane to 17α,21βC30hopance of lower Cambrian Maidiping and Qiongzhusi Formation is 0.35, 0.32 respectively. The ratio of V to V plus Ni of Maidiping and Qiongzhusi Formation is more than 0.54, and most of the ratio of Ni to Co are more than 7, these all reflects the anoxic sedimentary environment. So the lower Cambrian Maidiping and Qiongzhusi Formation is more reduction than the third member of the Sinian Dengying Formation.

The sedimentary facies of the third member of Dengying Formation and lower Cambrian Maidiping and Qiongzhusi Formations is tidal flat and continental shelf respectively. And we can observe bird's-eye structure in the third member of Dengying Formation. So we can speculate that when the third member of Dengying Formation deposits, the depth of water is shallower than that of Maidiping and Qiongzhusi Formations.

A more reductive sedimentary environment and deeper water may be a reason for the better quality of lower Cambrian Maidiping and Qiongzhusi Formations.

THE SEISMIC GEOMORPHOLOGICAL ANALYSIS OF TIDAL CHANNELS IN CRETACEOUS MISHRIF FORMATION OF CARBONATE PLATFORM ARABIAN GULF IRAQ

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In the carbonate platform the tidal channel reservoir developed in the environment with high hydrodynamic energy is favorable reservoirs with good physical properties. The characterization of tidal channel reservoir plays an important role in the exploration and development of carbonate oil fields.

In this paper, the methods of hierarchical calibration and seismic sedimentology are introduced into the characterization and prediction of tidal channels reservoir. The hierarchical calibration method is that the different data are integrated by the thin section-core calibration, core-logging calibration, and loggingseismic calibration to analyze the geological and geophysical characteristics of tidal channels. The seismic sedimentology method is used to analyze and predict the distribution characteristics and evolution rule of tidal channels in carbonate platform by the workflow as follows: (1) seismic horizon interpretation with interface constraints; (2) seismic attribute extraction and optimization; (3) geological interpretation of seismic attributes.

The result show that (1) The geological and geophysical characteristics of tidal channels: a) The lithology of tidal channel is mainly composed of grainstone and rudstone with medium sorting and grinding circle. The reservoir of tidal channel has large fragmentation degree of biological detritus and developed the multi-directional cross bedding; b) the tidal channels reservoir demonstrated low GR and high ILD in the logging response and low energy and weak amplitude in the seismic reflection. (2) Distribution characteristics of tidal channels: a) The tidal channels in study area have the characteristic of multi-channels, which are always split into two or more branch with the channel number increasing and channel width decreasing in the direction of the landward. b) The trunk tidal channels show the sedimentary characteristics of vertical accretion for the low sinuosity ($p < 1.3$). c) The branch tidal channels are controlled by the tidal energy. The branch tidal channels would be split into more branch tidal channels when the tidal energy was strong. However, some of the branch tidal channels would be abandoned when the tidal energy was weak.

The methods of hierarchical calibration and seismic sedimentology have significantly improved the cognitive accuracy of the tidal channel depositional model and reduced the prediction uncertainty.

SEQUENCE STRATIGRAPHY AND COAL ACCUMULATION OF THE EARLY CRETACEOUS COAL-BEARING SERIES IN THE ERLIAN BASIN, NE CHINA

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The Erlian Basin is located in the central northern Inner Mongolia Autonomous Region and, being rich in coal, oil, oil shale, gas, sandstone-hosted uranium deposits resources, has become one of the key research basins for China's low-rank coalbed methane exploration and development. The detailed depositional systems and basin evolution of the Lower Cretaceous coal-bearing series in the Erlian Basin of northeastern China were analyzed based on extensive borehole and outcrop data. A total of 19 distinct lithofacies were identified, which ranged from conglomerates, sandstones, siltstones, mudstones, shales, and marls, to coals. Seven depositional systems were suggested to have formed these lithofacies, including alluvial fan, fan delta, braided fluvial, braided fluvial delta, meandering fluvial, meandering fluvial delta, and lacustrine depositional systems. Five third-order sequences, each lasting approximately 9 Ma, were recognized and their internal lowstand systems tract (LST), transgressive systems tract (TST), and highstand systems tract (HST) were subdivided in each sequence based on six key sequence boundaries. These boundaries were represented by regional unconformities, basal erosional surfaces of the incised valley fills, inter-fluvial paleosols, and facies reversal surfaces. Sequences I to V correspond to the rift initiation stage, the early rift climax stage, the late rift climax stage, the immediate post-rift stage, and the late post-rift stage of the basin, respectively. The preferred sites for coal accumulation were the inter-distributary bay in the braided fluvial delta plain and the meandering fluvial delta plain, the shoreline to shallow lake, and the fluvial floodplain environments. The major coal seams accumulated during the early and late TST of sequences III, IV and V, which were well developed in the east and north of the Erlian Basin. The coal accumulation was controlled by the synsedimentary structures and paleoclimates. Three coal depositional models were summarized in the sequence stratigraphic framework. These results could provide the basis and guidance for the exploration and development of coal and CBM in the Erlian Basin, and the Jiergalangtu Sag, Huolinhe Sag, Baiyinhua Sag and A'nan Sag should be the key exploration areas.

CAMBRIAN HYDROCARBON MIGRATION SYSTEM AND RESERVOIR-CONTROLLING PATTERN OF ANYUE GAS FIELD IN SICHUAN BASIN, CHINA

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Great progress has been made through years of exploration in the dolomite reservoir of Lower Cambrian Longwangmiao Formation, more than 4500 m in burial depth in Sichuan Basin in 2013, with 779.9 km^2 proven gas-bearing area and $4403.8x10^8$ m^3 proven geological reserves in Moxi Block. But there are only 527.57x108 m^3 predicted geological reserves in Gaoshiti Block which is much smaller than nearby Moxi Block while the reason is not clear. So it is significant to study the main controlling factors for the difference to guide further exploration of Longwangmiao Formation. With a method of combining geologic analysis and experiment data analysis, this study is focused on the types of deep Cambrian migration system, and their controlling on the reservoir. The result indicates that the Cambrian migration pathway is one of main controlling factors of geological reserve difference between Moxi Block and Gaoshiti Block.

The Cambrian migration system includes normal fault, permeable sandstone and dolomite. Fault is the efficient pathway for vertical migration of oil and controls vertical distribution scope and scale of hydrocarbons. There are 37 faults in Moxi Block but only 14 faults in Gaoshiti Block. With the increase of fault number, scale and yield of hydrocarbon reservoir are gradually increased. The samples from sandstone of Canglangpu Formation are characterized by QGF spectral peak around 375 nm and QGF Index value generally greater than 2 which indicating the presence of migration pathway of palaeo oil. The QGF-E spectra for samples distribute in range of 30~500 pc and spectral peaks around 370 nm indicating presence of residual oil. So the sandstone of Canglangpu Formation was the pathway for lateral migration of oil and gas, and controlled planar distribution scope of hydrocarbons. There is large amount of bitumen in the dolomite reservoir of Longwangmiao Formation. The occurrence of the bitumen is dominated by dissolution pore-filling and fracture-pore filling. There is a positive correlation between the reservoir property and the content and occurrence of bitumen. And the reservoir properties in Moxi Block are greater than that in Gaoshiti Block. The permeable dolomite is not only the pathway for lateral migration of oil and gas but also the important hydrocarbon reservoir space. There is a positive correlation between the reservoir properties including porosity and permeability with the gas saturation. Under controlling of migration system, oil and gas generated from Cambrian source rock migrated upward along normal faults, migrated laterally along the sandstone of Canglangpu Formation and then initially accumulated in the dolomite reservoir with high porosity and permeability. The difference of migration system is one of important reasons for great difference of geological reserves between Moxi Block and Gaoshi Block.

A NEW EXPLORATION PLAY–CARBONATE SOURCE ROCKS OF LOW ORGANIC MATTER ABUNDANCE IN TABEI AREAS OF TARIM BASIN, CHINA

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Carbonate rocks exhibiting high thermal evolution and low organic matter abundance (TOC $\geq$ 0.5%) are widely distributed in Tabei areas of Tarim basin, China. At present, TOC = 0.5% is the standard of high abundance source rock in resource evaluation, most of which are carbonate rocks. But the distribution and scale of the high abundance source rocks with TOC $\geq$ 0.5% in the research area is limited, which is unreasonable for the discovered hydrocarbon scale. The evaluated hydrocarbon resource based on carbonate source rocks with high organic matter abundance (TOC> 0.5%) is even smaller than the proved reserves in the research area, indicating that carbonate source rocks with low organic matter abundance may contribute to oil-gas accumulation and can be a new exploration play.

The test results of carbonate rocks in research area show that as the depth or thermal evolution degree increase TOC of source rocks decreases; and hydrocarbon generation potential and residual amount increase and then decrease as the depth increase. Besides, the results of thermal simulation experiment which indicate the source rocks of low organic matter abundance can generate and expulse a great number of hydrocarbon. All of these indicate that the low abundance of carbonate rocks can be effective source rocks. Meanwhile, we find that a few factors could be considered to determine the lower limit of TOC in carbonate source rocks. The analysis suggests that the lower limit of TOC in carbonate source rocks is less than 0.5%, which is the standard of clay shale. The lower limit of TOC of the effective source rocks with different maturity was gained by the method of hydrocarbon generation potential and simulative calculation based on material balance principle according to the hydrocarbon expulsion threshold.

Combining study results and exploration practice we hold the view that: 1) The carbonate source rocks with high maturity and low organic matter abundance can be effective resource rocks in Tabei areas of Tarim basin, China. So does part of which with medium maturity; 2) The lower limit of TOC in effective carbonate source rock with low maturity medium maturity and high-over maturity stages respectively are TOC≥1.4% TOC =0.1%~1.44% and TOC <0.1%. The study reminds us that some carbonate source rocks with high mature degree and low organic matter abundance (TOC <0.5%) an make an effective contribution on the hydrocarbon accumulation and can be a new exploration play, which should not be ignored in the resource evaluation and the exploration of hydrocarbon.

THE RESERVOIR MODELING METHOD OF COMBINATION FREQUENCY-DIVIDED INVERSION WITH COKRIGING AND ITS APPLICATION

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Conventional seismic inversion technology has the disadvantages of low resolution and large error in reservoir prediction for large well spacing and poor seismic data areas. Therefore, this paper presents a reservoir modeling method of combination frequency-divided inversion with CoKriging in the Shahejie Formation of Gangzhong Oilfield in Bohai Bay Basin. Firstly, the original seismic data are divided into low frequency, medium frequency, high frequency (15Hz, 30Hz, 60Hz) data volume in different frequency bands, and the AVF relation is introduced into the inversion to obtain the frequency-divided inversion data volume. Then, the velocity model is used for time-depth conversion of the inversion data volume which then is resampled into the structure model in depth domain, and then the probability correlation between the lithofacies interpretation data of single well and the inversion attribute value is analyzed. Whereafter, the CoKriging interpolation method is used to establish the three-dimensional lithofacies model. What needs to be emphasized is that the modeling method is based on that the lithofacies interpretation data of single well is taken as the hard data, and the probability correlation between the lithofacies interpretation data of single well and the inversion attribute value is taken as the soft data of the lithofacies modeling. Finally, according to the sedimentary pattern, the sedimentary microfacies model is establish by adopting the single sand body embedded modeling method, in which the distribution of sand bodies are characterized by inversion profiles and lithofacies model slices, and the sedimentary microfacies interpretation data of single well is referenced. The application of the reservoir modeling method of combination frequency-divided inversion with CoKriging to the Gangzhong Oilfield shows that the three-dimensional sedimentary microfacies model obtained by this method is reliable. Therefore, the method can provide a reference for the fine reservoir characterization of similar reservoirs, which is both faithful to the single well interpretation data at the well point and the sedimentary pattern and the interwell seismic information are taken into account so that the reservoir prediction accuracy can be improved obviously.

SHALLOW WATER BRAIDED RIVER DELTA DEPOSITION AND DEEP RESERVOIR CHARACTERISTICS IN BOHAI BAY BASIN: A CASE STUDY OF PALEOGENE SHA2 MEMBER OF CHENGBEI LOW STEP FAULT BLOCK, HUANGHUA DEPRESSION, EASTERN CHINA

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Lithologic reservoir is mainly developed in Sha2 member of Paleogene Shahejie Formation of Chengbei low step fault block where sedimentary and reservoir characteristics study is in low degree in Huanghua depression. In this study, Sedimentary characteristic and favorable microfacies is defined based on core, well log data, seismic interpretation, analysis and testing data, combined with geological background of the study area. Results show that Sha2 member is during the period of rift lake basin transformation towards depression lake basin and the terrain condition is steep slope and gentle slope alternative distribution. Facies are shallow water braided river delta front and subaqueous fan at beginning of Sha2 member, and shallow water braided river delta front is mainly developed in the middle of Sha2 member. At last, deep lake facies is widely developed while delta front is limited. Microfacies are mainly underwater distributary, mouth bar, sand sheet, bay between distributaries. Because of provenance movement, lake level fluctuation, terrain difference and unstable hydrodynamic force, microfacies are different in shape, development degree, sand structure and sequence in vertical is absent. Underwater distributary and sand sheet whose sandbody has high quality in physical property are widely developed while mouth bar distributed limited and subaqueous fan can take as reservoir locally. Based on the core description, conventional thin section, cast thin section, scanning electron microscope (SEM), mercury intrusion porosimetry (MIP) and nuclear magnetic resonance (NMR) analysis, the physical properties of the shallow braided river delta sandstone reservoirs and the types of reservoir space of Sha2 Member in the study area have been analyzed. The characteristics and controlling factors of Sha2 reservoirs are examined to reveal the causes for the formation of deep highquality reservoirs (more than 4000 m). Sha2 reservoirs in the study area are the gravel rock, pebbled inequigranular sandstone, medium sand, and gritrock. The lithology is mainly lithic feldspar sandstone and feldspar lithic sandstone, the contents of rigid particles like quartz and metamorphic rock cuttings are higher, the content of matrix is very low, the structure is particle support. The average porosity is 13.1%. The average permeability is $2.3\text{x}10^{-3}$ μm^2. The reservoir type is low porosity and low permeability. The reservoir space is mainly primary pores and secondary pores. Parent rock type, sedimentary environment and the abnormal high pressure in the Sha2 Member are the dominant factors controlling the reservoir properties. It is inferred that high quality sandstone reservoirs with high natural productivity of oil and gas are widely developed in the strata more than 4000 m deep in the Bohai Bay Basin, the conventional sandstone reservoir exploration is expected to expand to the deep.

CHARACTERISTICS AND PRELIMINARY STUDY ON GENESIS OF BLACK ROCK SERIES OF UPPER PERMIAN DALONG FORMATION IN HEFENG AREA, HUBEI PROVINCE, CHINA

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According to detailed observation of the 6 outcrop sections and HD1 well, and in combination with polarizing microscope, X-ray diffraction (XRD), field emission scanning electron microscopy (SEM) and organic carbon content (TOC) analysis, the petrological and mineralogical characteristics of black rock series of Upper Permian Dalong Formation in Hefeng area, Hubei Province, is studied. There are three rock types of shale, carbonate and silica rock in Dalong Formation which with high content of organic matter and composed of black rock series. Shale is the main rock type, carbonate and silica rock are as thin layers among shale. The petrological characteristics of black rock series is advantageous to the influence of late diagenetic fluid and the forming of hydraulic fracturing in the shale gas development phase. It can be divided into 6 lithology sections in vertical of Dalong Formation, which reflect the sedimentary water body had experienced twice deep-to-shallow evolution processes, and Dalong Formation can be divided into two sequences. The origin of quartz is dominated by biogenesis and diagenesis, however, the diagenetic silica is the main type, and clastogene is the least. The formation of black rock series in Dalong Formation is mainly affected by oxygen reduction environment in platform shelf facies, which influenced by the retention of the carbonate platform in the circle of platform shelf on three sides meanwhile possibly influenced by upwelling action in deposition process and also the hot water should be considered, which related to the syngenetic faulting.

THE FORMING MECHANISM AND PROCESS OF TIGHT OIL SAND RESERVOIRS: A CASE STUDY OF CHANG 8 OIL LAYERS OF THE UPPER TRIASSIC YANCHANG FORMATION IN THE WESTERN JIYUAN AREA OF THE ORDOS BASIN, CHINA

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Tight oil has become a hotspot in the field of petroleum exploration and development. In China, tight oil is mainly distributed in the lacustrine basins, such as Triassic of Ordos Basin, Jurassic of Sichuan Basin and Cretaceous of Songliao Basin. Triassic Yanchang Formation of Ordos Basin has advantageous tight oil accumulation conditions, which has been proved that it has good exploration potential in the production practice. Understanding the control and evolutionary process of tight oil sand reservoir quality are critical for basic research and commercial production of tight oil. In this study, we take the Chang 8 oil layers of the Upper Triassic Yanchang Formation in the western Jiyuan area of the Ordos Basin for case. On the basis of sufficient collection and application of geological data in the study area, we collect core samples, conduct pressure-controlled mercury injection (PMI), scanning electron microscope (SEM), X-ray diffraction (XRD), and isotope testing experiments and analyze the data. The characters of lithology and diagenesis, tightening mechanism and tightening process of tight oil reservoir have been analyzed in detail. Then the coupled relationship between reservoir tightness and hydrocarbon accumulation have been ascertained. Four conclusions were reached.

1) Chang 8 tight reservoirs, mainly lithic arkose and feldspathic litharenite, had experienced diagenesis such as mechanical and chemical compaction, cementation, replacement, and dissolution, performing as the extra-low porosity (av. 7.64%) and ultra-low permeability (av. 0.473 mD) with intensive heterogeneity. The pores are mainly primary intergranular pore and secondary dissolution pore, and belong to extrasmall pore and micro-fine throat. The reservoirs are at late period of mesogenetic A stage.

2) The sedimentary and diagenetic factors jointly lead to the tightness of Chang 8 reservoirs. The sedimentary environment where sand bodies are close to the provenance with lacustrine level rapidly increasing provides the innately decisive factors for reservoirs tightness. These near-provenance sediments record low maturity of the original mineral composition and relatively poor to medium sorting which are inclined to undergo intensive compaction. The initial porosity decreases rapidly due to compaction and cementation with the porosity loss rate are 49.42% and 40.87%, respectively. While the effective porosity increasing rate caused by dissolution is only 8.47% with insignificant improvement of reservoir quality. The intensive compaction, intensive cementation, and weak dissolution are the crucial diagenetic factors for reservoir tightness.

3) The tight process of Chang 8 reservoirs comprised four stages: compaction causing rapid pore reduction, early cementation causing additional pore reduction, dissolution causing limited pore increase and late cementation causing tightness.

4) The porosity was below 10% during hydrocarbon charging period, probably indicating that reservoir had already been tight before hydrocarbon accumulation, and it pertains to typical tight oil reservoirs.

FORMING MECHANISM AND MAIN CONTROLLING FACTORS ON THE HIGH-QUALITY CARBONATE RESERVOIRS RESTRICTED BY PALEOKARST BACKGROUND: A CASE STUDY OF MA 541 SUBMEMBER OF ORDOVICIAN IN WUSHENQI-ZHIDAN AREA OF THE ORDOS BASIN, CHINA

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Carbonate reservoirs have become a crucial part in the field of petroleum exploration and develoment. In China, carbonate reservoirs are mainly distributed in Early Paleozoic of Ordos Basin, Paleozoic of Sichuan Basin and Paleozoic of Tarim Basin. Early Paleozoic of Ordos Basin has advantageous carbonate reservoir formation conditions, which has been proved that it has good exploration potential in the production practice. Understanding the controlling factors of carbonate reservoir quality is critical for basic research and commercial production of oil and gas resources.

In this study, we take the Ma 541 carbonate reservoirs of the Ordovician in the Wushenqi-zhidan area (WZA) of the Ordos Basin for case. On the basis of sufficient collection and application of geological data in the study area, we collected core samples, observed the geological section, core samples and thin sections, conducted pressure-controlled mercury injection (PMI), scanning electron microscope (SEM), Xray diffraction (XRD), Cathodoluminescence (CL) and analyzed the data. The characters of lithology and reservoir spaces, karst paleogeomorphology (KPG) types and karstification types of Ma 541 carbonate reservoirs have been analyzed in detail. Then the main controlling factors on the high-quality carbonate reservoirs development have been ascertained. Four conclusions were reached.

1) Ma 541 carbonate reservoirs, mainly muddy micrite dolomite, micrite dolomite with anhydrite nodule, gypsum dolomite, evaporite and paleokarst breccias, had experienced complex diagenesis such as dolomitization, gypsification and degypsification, dissolution, cementation, and dedolomitization, performing as the extra-low porosity (av. 3.39%) and ultra-low permeability (av. 0.883 mD) with intensive heterogeneity. The reservoir spaces are mainly dissolution mold pore, primary intergranular pore, intergranular solution pores and microcracks.

2) Based on the regional tectonic setting and stratigraphic distribution, the compensation thickness impression method (CTIM, the stratum thickness from the Maoergou limestone to the bottom of Benxi Formation) was used to rebuild the KPG of Ordovician which includes three types of second-order KPG and five types of third-order KPG in WZA. The three types of second-order KPG include karst highland, karst slope and karst basin from west to east, and the five types of third-order KPG include tableland, shallow depression, monadnock, groove and depression.

3) The WZA experienced three types of karstification including contemporaneous interlayer karst, shallow burial weathering karst and burial karst to form lots of various pores and holes.

4) The development of high-quality carbonate reservoir is mainly controlled by KPG and late diagenetic dissolution. The former controlled reservoir distribution, physical property, gas and water distribution within the reservoir, so it is the basic condition to form the high-quality reservoir. And the later one reformed the pore system produced during karstification through three-periods of diagenetic dissolution. Therefore, the superimposition of these two geological processes is the key to the formation of high quality reservoirs in WZA.

TESTING THE IMPACT OF ASTRONOMICAL CLIMATE FORCING ON FLUVIAL ARCHITECTURE IN PROCESS-BASED NUMERICAL MODELLING

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Variation of orbital parameters results in cyclic climate change embodied in large variations of precipitation, evaporation, storminess, and with that vegetation, runoff, sediment supply, and base level. It was recently made tentative that the 21-kyr precession cycle pace cyclic occurrence of river avulsion contrasting with phases of stable overbank sedimentation in the Eocene Willwood formation of the Bighorn Basin, Wyoming. Here, we use a process-based numerical model of Karssenberg and Bridge (2008) to test factors that might cause this cyclic building of alluvial architecture.

In the model, river enters the basin at the inflow point, and transiently leaves it downstream. The channel follows the direction of the largest gradient, which means bifurcation and avulsion may take place at the location when the cross-valley slope is larger than the down-valley one. Sensitivity tests concerned basin size, initial basin slope, average discharge and sediment load. Parameters were where possible set to mimic Bighorn basin scenario. Subsequently, we ran > 40 kyr scenarios with stable parameters and with cyclically changing discharge and sediment load to mimic orbital-scale climate change. Cycle length was set to 10 kyr to shorten computer time needed for model runs. Discharge and sediment load were both set in-phase and out-of-phase and tested separately with the other parameter set stable. Tectonic subsidence was mimicked by continuous base-level rise set at accommodation space creation rates measured in the Bighorn Basin.

We find a near random river bifurcation and avulsion timing and spacing for the runs with stable input parameters. When either discharge or sediment load varied cyclically, river avulsions start to be ordered by the cyclic changes, while ordered river avulsion phases occur in the runs with out-of-phase cyclic water discharge and sediment supply. These runs show river avulsion filling the floodplains during phases of decreasing runoff and increasing sediment supply lasting quarter of the cycle. The other three quarters of the climate cycle, relatively stable overbank phases occur. These results are strikingly similar to the orbital-climate sedimentary model constructed based on field observations by Abels et al. (2013). Decreasing water discharge and increasing sediment supply are favourable for avulsion due to increasing gradients. This causes more rapid increases of elevation of the channel beltsand thus increasing the cross-valley slope leading to avulsion.

PLIOCENE SEISMIC STRATIGRAPHY AND DEEP-WATER SEDIMENTATION IN THE QIONGDONGNAN BASIN, SOUTH CHINA SEA: SOURCE-TO-SINK SYSTEMS AND HYDROCARBON ACCUMULATION SIGNIFICANCE

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This study uses high-quality two-dimensional (2-D) seismic and well data to analyze seismic stratigraphy and deep-water Pliocene sediments in the Qiongdongnan Basin (QDNB), South China Sea. Eight major seismic facies were identified based on the amplitude, continuity, configuration, and external geometry of seismic reflections. Among them, sigmoid progradational configurations, oblique progradational configurations, mound-shaped chaotic configurations, and mound-shaped hummocky configurations are newly identified seismic facies indicative of provenance and water system significance. They were interpreted as a Pliocene-aged eastern shelf-edge delta, a western shelf-edge delta, and eastern and western submarine fans in QDNB. Consequently, two sets of Pliocene shelf-edge delta-continental slope canyon-submarine fan systems were established in the QDNB. From the approximately NNW-SSE progradation of the shelf-edge delta, the characteristics of the approximately NEE-SWW distributed continental slope system, and the definition of a source-to-Sink system, as well as previous heavy mineral research, we conclude the existence of two Pliocene sources from Hainan Island in the northern QDNB, corresponding to the Lingshui River and Wanquan River. Two independent and complete source-to-Sink systems (S2S-2, S2S-3) were distinguished from the northern Hainan Island to the basin area. S2S-2 is located in the western QDNB, which includes the Lingshui River-western shelf-edge delta-continental slope canyon-submarine fan. This source-to-Sink system has more sand-rich material and better reservoir conditions than S2S-3 in the eastern basin, predominantly due to a higher quality granite parent rock, abundant provenance, and a large-scale delta and submarine fan.

PROVENANCE AND FACIES OF THE NEOPROTEROZOIC BADAMI GROUP, KALADGI BASIN EXPOSED BETWEEN GOKAK AND BELAGAVI TOWNS OF KARNATAKA, INDIA

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The Neoproterozoic Badami Group occupies the southern and western sectors of the Proterozoic Kaladgi Basin and overlies unconformably the Archaean Dharwarian Basement of granite-gneiss-greenstone rocks and also partly the folded sediments of the older Mesoproterozoic Bagalkot Group from the Kaladgi Basin. Very few dedicated studies have been undertaken to study the 300 m thick sedimentary succession of this Group. Earlier workers have inferred a spectrum of depositional environments ranging from transgressive suite on a shelf, partly estuarine, tidal flat with dominant sandflat and subordinate mudflat and a telescopic mixed flat, braided fluvial system to shelf macrotidal sandstone bars for the Badami Group of sediments. In order to understand the depositional conditions and settings of these sediments, provenance and facies analyses were carried out covering exposures between Gokak and Belagavi towns where the Badami Group has good contiguous exposures.

24 lithosections were constructed and petrographic studies of 50 samples were carried out for this purpose. Three main facies namely the sandstone, shale and limestone and their subfacies were identified during this study. These were studied from a process response point of view and based on their physical and petrographic characters, it has been inferred that the sandstone facies at base (above the unconformity) are dominantly fan deposits that grade upwards into braided fluvial deposits, which further grade upward and westwards into transitional marine deltaic deposits. The shale-limestone facies occupy smaller but deeper pockets of the basin and show characteristics of shallow marine deposits which may have been deposited in mud and carbonate flats.

The provenance studies indicate that supply of detritus was dominantly from the Archaean greenstone-granite-granitoid terrain with some inputs from the older Mesoproterozoic Bagalkot Group of the Kaladgi Basin, in these western exposures between Gokak and Belagavi towns.

DIFFERENTIAL COMPACTION ON PASSIVE MARGINS: CONTROLS ON THE SEDIMENT DISTRIBUTION AND PETROLEUM SYSTEMS

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Differential compaction is a process that occurs during burial in nearly all sedimentary basins around the globe. It can form features at outcrop (metres) to seismic-scale (kilometres). Many studies have focussed on the seismic expression of structures related to differential compaction, providing qualitative analyses on large, discrete structures, but rarely quantify smaller structures. This presentation will look in detail at how differential compaction influences petroleum systems and seafloor sediment distribution. High quality 3D seismic data from Espiríto Santo Basin, offshore Brazil, were interpreted to quantify the magnitude and timing of differential compaction. Statistical methods and seismic attributes were used to analyse structures over a) a mass-transport deposit (MTD), b) submarine channel complex.

In both the MTD and channel complex, differential compaction was controlled by discrete lithological variations. During progressive burial of the features, compaction related anticlines formed over individual slide blocks and the channel axes. Coarse-grained siliclastics deposited along the axis of the channel complex created a broad anticline after only 200 m of burial. Small, isolated channels within the complex accumulate coarse-grained sediment downslope of knickpoints. Differential compaction over these isolated channels led to anticlines with four-way dip closure, forming effective structural traps.

Lithological variations in the MTD lie between carbonate remnant or rafted slide-blocks, and the surrounding muddy-debris flow matrix. The limestone compacted less than the muddy matrix during burial, forming broad anticlines over larger blocks (> 5 km wide) and narrow, repetitive anticlines over smaller blocks.

Petroleum systems in these areas are strongly influenced by differential compaction. Coarse-grained siliciclastic sediment ponds within depocentres, structural traps form over reservoir strata, and fine-grained sediments overlying the reservoir strata act as seals. A caveat in these findings are without borehole data in the study area, it is hard to predict reservoir architecture within these features. However, differential compaction both above the channel and the MTD exerts a clear control on the sediment distribution of a basin.

This information can also be used to understand possible effects of differential compaction during the burial of more recent MTDs close to the surface today. This is vitally important when choosing where might be best to place any anthropogenic structures in the future to ensure minimal subsidence beneath it.

THE INFLUENCE OF DEEP SOUTHERN COMPONENT WATER ON SEDIMENT DYNAMICS AT THE ARGENTINE CONTINENTAL MARGIN

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The deep southern component water (SCW) at the Argentine continental margin is a major component of the global oceanic circulation. It comprises the Lower Circumpolar Deep Water (LCDW) and the Antarctic Bottom Water (AABW). It has been suggested that the water mass structure in the deep Atlantic changed significantly during the last glacial/interglacial cycle. However, due to the lack of carbonate as a result of highly corrosive water masses in the deep South Atlantic, stratigraphic control in sedimentary records is often lacking. Thus, paleoclimatic and paleoceanographic records of deep SCW flow strength remain sparse.

Here, we demonstrate a continuous southern-sourced terrigenous sediment supply to our core sites at the deep Argentine continental margin since the Last Glacial Maximum (LGM). Based on clay mineral investigations, the persistent deep SCW flow induced the formation of elongated contourite drifts at the deep Argentine continental margin, e.g., on the Necochea Terrace. Results from the paleocurrent proxies terrigenous sortable silt mean (SSmean) and percentage (SS%) indicate three coherent deep SCW paleo-current records. Our results shed light on deep-water circulation and deep SCW flow strength in the Southwest Atlantic since the LGM. Based on increased terrigenous SSmean, SS% and fine sand contents, we propose enhanced deep SCW flow strength from 14 to 10 cal ka BP and weaker flow strength during LGM, early deglacial, and Holocene.

Reduced carbonate content was observed at our core sites from the LGM until 13 cal ka BP. We infer an oceanographic configuration that reveals a shallower northern component water (NCW) until 13 cal kaBP, thereby providing space for CO_3 under-saturated deep SCW. From 13 cal ka BP on, increased carbonate contents indicate that well-ventilated NCW expanded vertically leading to a deeper NCW-SCW interface.

This expansion of CO_3 saturated deep NCW significantly changed chemical deep-water properties in the Southwest Atlantic and caused enhanced carbonate preservation. We also suggest that NCW had a direct influence on deep SCW flow strength. Our results show a vertical contraction of the deep SCW by NCW reinitiation and a consistent migration of the high-energetic LCDW/AABW interface occupying our core sites during the late deglacial.

CONTOURITE INDUCED TURBIDITY CURRENT ACTIVITY IN THE MAR DEL PLATA CANYON (ARGENTINA)

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Submarine canyons are supposed to be direct conduits for sediment exported from the shelf into the deep sea. However, blind canyons, which are strictly confined to the slope and do not have a connection to the shelf, make up 74 % of all submarine canyons along the Southeast American margin. However, although this canyon type is most common at continental margins, its evolution and the oceanographic factors controlling the sedimentary processes are still poorly understood.

The Mar del Plata Canyon on the Argentine continental margin is incorporated into a major contourite depositional system. The canyon head originates on the Ewing Terrace at about 1000 m water depth and acts as a sink for contouritic material delivered along the terrace by the intermediate southern component water (SCW) nepheloid layer. Its downslope track crosses all intermediate and deep-water masses that shape the continental slope off Argentina. The canyon expires on the Necochea Terrace (3500 m to 3900 m water depth).

The studied sediment cores provide three millennial scale records along the canyon thalweg and on the Necochea Terrace covering the past 20,000 years. A significant feature of all cores is that turbidites only occur in the sediment sections covering the period from the Last Glacial Maximum (LGM) to the late deglacial. During LGM and early deglacial, turbidites are more abundant at the distal northern canyon flank whereas they are rather sparse in the exit to the abyssal plain. Due to persistent deep SCW flow, suspended sediment clouds were deflected to the north along the Necochea Terrace and resulted in a contour current controlled distribution pattern over the terrace. During the late deglacial most turbidite beds thinned out within the distal sector of the canyon or did not reach the distal canyon area at all. Holocene sections at all studied locations do not reveal any turbidites.

A distinct and similar grain-size distribution and mineralogical composition of all turbidite beds points to a contouritic source, most probably from the southern Ewing Terrace. Under glacial conditions, an intermediate SCW nepheloid layer induced sediment deposition along the inner part of the Ewing Terrace. In upper parts of the canyon V-shaped patterns indicate areas of instability where retrogressive failures were induced when pore water pressure was exceeded. Specific knickpoints identified along the thalweg are assumed to act as hydraulic jumps to transform small-scale slides into turbidity currents.

In conclusion, we state that turbidity current activity in the Mar del Plata Canyon is related to strong contour currents causing high sediment supply. Then, the temporary accumulated sediments became unstable, started sliding, and subsequently transformed into turbidity currents.

CLAY MINERALS AS GEOCHEMICALAND FACIES INDICATORS OF AN INTERCRATONIC RIFT BASIN

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Formation and composition of organic rich pelitic rocks are related to lithofacial characteristics of the synand postrift phases from Devonian to Serpukhovian age of the intracratonic Dniepr-DonetsBasin. The investigation area is situated in the north-western part of the basin. Well core samples of a depth range from approximately 2.8 to 6 km are correlated in a longitudinal profile and four cross sections. The mineralogical distribution and the variety of clay minerals, nonclays, accessory minerals and trace elements of black shales, analysed by XRD and XRF, reflect the depositional conditions and the impacts of tectonical processes. For each investigated horizon within the regarded Paleozoic succession the mineralogical variability and changes are discussed taking into account findings of basin modelling, sea level changes and source rock potential. Included well logging data give indications of the cyclicity of the sedimentary deposition, data of Rock-eval pyrolysis serve for the validation of S and C-contents.

The Late Devonian syn-rift phase is associated with mafic to intermediate magmatism. Increased chlorine values indicate the effect of salt tectonics. In the outermost north-western part of the basin a Devonian sequence with a thickness up to 2 km reflects the proximity to the sediment source and shows varying contents of mica-group minerals, expanded clays, mixed layer clays, chlorite and kaolinite. In the lower part of the succession poorly crystallised mica-group minerals and glauconite occur. The degree of the crystallinity of the mica-group minerals increases within the succession. Regarding the nonclays the high amount of feldspars, plagioclase as well as K-feldspars is obvious. In the Devonian succession the quartz content is generally lower compared to carboniferous layers. Along the basin rims carbonate production is indicated by high calcite values. In south-eastern direction of the basin downwarping occurs, and core samples are to a less extent available because of the rising depth. A significant kaolinite horizon forms the basis of the Caboniferous succession.

The post-rift phase, regarded from Tournaisian to Serpukhovian age, is characterised by transgressive-regressive cycles. Along the axial zone of the basin eustatic sea-level rises resulting in deep-marine conditions. Trace element ratios and C-S-Fe relationship indicate the anoxic conditions. The Tournaisian succession is marked by a sharp inserting of a predominat occurrence of detrital kaolinite. The Lower Visean is related to an overall transgressive trend with the development of carbonate platforms. Shale samples of the lower Visean indicate an overall transgressive trend and the development of small carbonate platforms.

Kaolinite represents the dominant clay mineral. The quartz content decreases and an increase of pyrite and siderite is apparent. An overall regressive trend is assigned to the Upper Visean succession with a distinct change in the mineralogical composition to the Lower Visean. This refers to an increase of mica-group minerals, mixed-layer minerals (primary illite-smectite), a decrease of kaolinite (except in the deepest parts of the basin) and an increase of quartz. Serpukhovian shales can be related to shallowand lacustrine sedimentation.

THE FORMATION MECHANISM OF LACUSTRINE COQUINA-BAR: A CASE STUDY OF LOWER JURASSIC DAANZHAI MEMBER IN SICHUAN BASIN

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As an important carrier of dense oil, Daanzhai (Lower Jurrassic) lacastrine coquina-bar host extensive distribution in Sichuan basin. Based on systematric petrology characteristic, carbon-oxygen isotope, paleontology characteristics and analogy with coquina-bar and modern bioclastic-bar, this paper provides an integrated discussion of the formation mechanisim of lacustrine coquina-bar.

There are three main types of lacustrine rocks of Daanzhai member in the study area identified and which are classified as bioclastic limestone rich organic mud rock, and transitional rocks. The bioclastic limestone indicates strong hydrodynamic, weak reductive environment which corresponds to shallow lake deposition. The rich organic mud indicates weak hydrodynamic and strong reductive environment which corresponds to deep lake deposition. Of course, the transitional rocks indicate a transitional environment and corresponds a transitional deposition. The results of more than 70 samples show that the values of the $\delta^{13}C$ vary from -3.28 ‰ to 7.0 ‰ (except for three negative values), and the values of $\delta^{18}O$ vary from -14.41‰ to -1.33‰. Compared with the isotope values of marine and continental carbonate rocks the ancient climate of Sichuan Basin is characterized by relatively warm and humid subtropical and tropical climatic conditions, and the ancient lake is characterized by inland open lake without obviously seawater intrusion during the Daanzhai period. The warm and humid climate conditions are extremely beneficial for lake organisms, especially for the species of coquinas, which reproduce and form large deposits. According to the microscopy results, the biological particles are mainly bivalves (lamellibranch), and others are gastropods, ostracodes, and charophytas etc. Bivalves are so developed during the Daanzhai period that they are beyond doubt the main constructors of coquina-bar. The embayment of Shark Bay is described as a modern day analogue for coquina-bar, which shows that coquinas were always deposited by waves, surges and swash and form the coquina-bar in a landward direction.

GENETIC TYPES AND DISTRIBUTION OF DEEP-WATER GRAVITY FLOWS IN SOUTHERN CHANGLING FAULT-BASIN DURING RIFT EXPANSION

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Gravity flow deposits are a principal component of deep-water systems. Previous research is focused on the deep-marine sedimentary records rather than the lacustrine. The gravity flow deposits in lacustrine are strongly controlled by synsedimentary faulting and paleo geomorphological characteristic. The study was based on the differences on the sediment composition structure, transportation sedimentation mode, fluid rheological characteristics, and made full use of drilling core, well logging, seismic explanation and other data. We carried on the gravity flow types, gravity flow association characteristics and genetic mechanisms of gravity flows.

The results are as follows. During the sedimentary period of Yingcheng formation, the southern Changling fault-basin can be divided into three paleogeomorphology units, which are southwestern faultslope zone, southeastern steep slope zone and northern depression belt. The paleogeomorphology steepened gradually from west to east. Faulted troughs formed by synsedimentary fault which were the main sand transporting channel. There are five gravity flow types developed in southern Changling fault-basin, including the mud-only turbidite, low density turbidite, high density turbidite, sandy debris flow and muddy debris flow. According to trigger mechanism and sedimentary facies sequence characteristics, the gravity flow association divided into two types, slumping gravity flows and flooding gravity flows. The fluid properties conversion of the gravity flow association which caused by flooding are divided into three process, including water-rising stage (low density turbidite-debris flow), flood peak stage (debris flow-high density flow), water-recession stage (low density turbidite-mud-only turbidite). The fluid properties conversion process of the gravity flow association caused by slumping are divided into four subprocesses, including slides and slumps, sandy debris flow, high density turbidite, low density turbidite and mud-only turbidite. The gravity flow sedimentary characteristics of different tectonic-paleogeomorphology have been established. In southwestern fault-slope zone, affected by the flood effect, terrigenous debris were transported along the faulted troughs into lacustrine and fan delta developed. Because of the development of slope break belt, the sublacustrine fan was developed by the slumping of fan delta front in northern depression belt. In southeastern steep slope zone, influenced by the tectonic activity, debris slumped into semi-deep lake and formed nearshore subaqueous fan.

ROCK TYPES AND CHARACTERISTICS OF TIGHT RESERVOIR IN SHAHEZI FORMATION, LONGFENGSHAN SUBSAG, CHINA

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A large volume of tight reservoir is developed in Shahezi Formation, Longfengshan subsag. However, previous reservoir characterization efforts take little attention to rock types and characteristics which play important role in the heterogeneity of tight reservoir. Consequently, this research presents an integrated rock types and characteristics description based on core observation, thin section observation TOC measurement X-ray testing and high pressure mercury penetration. The research results show that the tight reservoir of Shahezi formation in Longfengshan subsag has a complex mineral composition and multiform rock composition which consist of the mixed sedimentary rock class of terrigenous debris, pyroclastic debris and carbonate. Hydrocarbon source rocks developed near the tight reservoir, which benefits reservoir quality because of the organic acids dissolution. Therefore, rock naming is based on the three – members which including the content of carbonate, pyroclastic debris and terrigenous debris, with the organic components in hydrocarbon source rock near the reservoir. So as to establish the division of rock types named “three members four components”. Tight reservoir rock types are divided into four main classes which are mixosedimentite, pyroclastic rocks, carbonate rocks and terrigenous debris rocks based on that. According to the rock component content, using the debris “triple nomenclature”, subdivided into 18 specific classes. Among them the rock types of “up sweet-spot” are pyroclastic mixosedimentite and pyroclastic rocks which are mid-rich in organic matter, the rock types of “down sweet-spot” are terrigenous mixosedimentite, terrigenous debris rocks and carbonate rocks which are poor-mid in organic matter. Due to the great development of secondary porosity and connectivity of pore throat, the geological condition of “up sweet-spot” is more beneficial to hydrocarbon accumulation, and the “down sweet-spot” has more carbonate rock class components whose brittleness is more advantageous to the fracturing modification of reservoir.

MICROSCOPIC PORE THROAT CHARACTERISTICS OF GRAVITY FLOW SANDSTONE RESERVOIRS OF YINGCHENG FORMATION IN LONGFENGSHAN SUBSAG, CHINA

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Gravity flow deposits are important components of many lacustrine systems including those forming hydrocarbon reservoirs which are products of faulted basin landslides. The improvement of mercury injection technology helps us to visualize the complex pore structure. However, the pore-throat characteristics are often associated with gravity flow types, which commonly have different sedimentary characteristics. The gravity flow sandstone reservoirs of Yingcheng Formation in southern Changling fault-basin provide an integrated subsurface and mercury injection study highlight the role of pore throat characteristics in different gravity flow types. Yingcheng Formation in southern Changling fault-basin mainly developed five kinds of gravity flows including mud-only turbidite, low density turbidite, high density turbidite, sandy debris flow and muddy debris flow. Different types of gravity flow sediments have similar pore radius distribution and various pore throat ratio if porosity is assumed to be the same. The sediments of high-density turbidities and low-density turbidities have big throat radius and thick pore throat which radius more than 1 m, and their low void ratio has concentrated distribution. The development of thick pore throat and the low pore throat ratio improve the contribution of pore connectivity to the permeability which is a necessary condition for hydrocarbon migration and accumulation. The sediments of muddy debris flow, sandy debris flow and mudonly turbidities have small throat radius and fine pore throat which radius less than 1 m, and their high void ratio has dispersed distribution. Such pore structure affects pore connectivity; as a result, permeability is reduced. However, it plays a significant role in reservoir seal. According to the differences in development characteristics and distribution, the sand body of gravity flow has different pore throat structure and physical property, and further controlled the differences of hydrocarbon migration and accumulation of different sedimentary positons in gravity flows.

RANDOM LINK BETWEEN ACCOMMODATION SPACE, INNER-PLATFORM FACIES DISTRIBUTION AND SEDIMENT THICKNESS (HOLOCENE-PLEISTOCENE, BAHAMAS)

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Shallow-water carbonate platform successions have been studied intensively to determine if the observe repetition of facies variations may reflect variations in sea-level related to climatic variation linked to orbital variations, the Milankovitch frequencies. It is often assumed that these shallow-marine carbonates completely fill the available accommodation space on the shallow-water carbonate platforms. By doing so it is assumed that the sediment thickness of a single depositional cycle is a direct measure of the amplitude of relative sea-level change. New seismic data from Great Bahama Bank, however, reveal that the accommodation space created during the Holocene sea-level rise is filled in a rather irregular way. The seismic data showed the occurrence of three distinct seismic horizons: the seabed, the Pleistocene top, and a lower Pleistocene karst level. In total, 326 in-situ water-depth measurements validated the upper limit of the present accommodation space. The analysis showed that no correlation existed between the available accommodation space, the Holocene sediment thickness and the waterdepth. The hydrodynamic energy distribution with the inner platform area appeared to be the dominant control with mud-dominated sediments occurring in shallow low-energy areas, protected by a topographic barrier, whereas mud-free coarse-grained sediments mainly occurred in deeper, high hydrodynamic energy areas with strong tidal currents, ocean-water influx and winds. The redistribution and off-bank transport of sediment as a result of the aforementioned uneven energy distribution leads to variations in the carbonate-cycle thickness on the platform, and shows that the cycle-thickness link cannot be used to reconstruct the amplitude of suborbital sea-level change during highstands in sea level. In addition, the actual water depth and the inner platform facies distribution did not show a direct correlation, which contrasts with a rule of thumb used by many when studying fossil inner platform carbonate deposits.

INTEGRATED CORE ANALYSIS: AUTOMATED MAPPING OF DIAGENETIC ANOMALIES AND PROVENANCE CHANGES FOR RESERVOIR-QUALITY ASSESSMENT

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Sedimentary rocks are of key economical and societal importance because they contain natural resources such as hydrocarbons, drinking water and geothermal energy. Understanding the mechanisms which control their heterogeneity and spatial distribution is crucial for assessing their reservoir quality. Reservoirquality analysis (RQA) relies on integration of seismic, well-log, core and cutting data. Of these, only cores provide an intact sample of the sedimentary rock, which permits various parameters, such as mineralogical composition, texture, diagenetic alterations and porosity-permeability distribution to be measured. RQA of cores relies to a large extent on thin-section-based petrographic analysis, a time-honoured technique which has given us unprecedented insight into mineral composition and texture of reservoir rocks. However, owing to the cost-, time-, and labour-intensive nature of thin-section analysis, sampling is generally sparse and barely sufficient to assess spatial correlations among properties. Extrapolation of sparse spot measurements across the entire volume of a reservoir is therefore highly challenging. Quantitative RQA may be taken to a new level by using X-ray Fluorescence core-scanning (XRF-CS) technology which permits spatially continuous, objective cm-scale analysis of cored reservoir intervals. Development of a log-ratio-based multivariate calibration algorithm for XRF-CS data has paved the way to systematic investigation of the following issues: (1) Calibration of XRF-CS data to mineralogical/ petrographic analyses of thin sections for automatic detection of anomalies resulting from diagenetic and provenance changes; (2) Development of protocols for processing of XRF-CS data for high-resolution RQA, validated against core and well data; (3) Extrapolation of measured properties to the scale of entire reservoirs, and refinement of well-to-well correlation based on down-core patterns of anomalies. Components of the workflow will be illustrated by means of sediment cores from marine Holocene, aeolian Permian, and fluvial Carboniferous settings.

MODELLING OF SELECTIVE SORTING FOR PROVENANCE AND PALAEOCLIMATE ANALYSIS OF SEDIMENTS: AN OLD PROBLEM REVISITED

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The petrographic and mineral composition of sediments (and therefore also their chemical composition) varies strongly with grain size. Hydraulic sorting of sediments may therefore have a profound influence on their bulk composition. Successful elimination of this source of variability will increase the power and resolution of (bulk) geochemical and petrographic techniques, and of single-grain techniques used to infer provenance. In addition, it will help us to better understand the variability of grain-size distributions of sediments. One method to correct for hydraulic sorting using bulk properties has been successfully applied to modern deep-sea cores. In this contribution, we will focus on a new grain-based approach inspired by Garzanti et al. (2009), which will be illustrated by means of grain-size data and heavy-mineral assemblages in modern sands. The variability of such data is governed by two main factors: provenance and selective transport. Although it is not possible to reconstruct the time evolution of selective transport, one can objectively quantify the "degree of sorting" of for instance grain-size distributions by making use of the physical properties of mineral grains (size, shape, density) to restore them to a "reference state" which may be expressed in terms of a characteristic distribution of terminal fall velocities of grains in air or water. Several examples of this new method to analyse sediments will be presented. The complexity will be gradually increased from a case in which sediments of identical provenance and grain size are considered to represent different stages of placer formation, via analysis of grain-size records, to analysis of heavy-mineral assemblages representing different provenances and spanning multiple grain-size ranges. Our approach, which can ultimately be traced back to the notion of "hydraulic equivalence" is not new, but we present the first successful multivariate implementation of a grain-based method to decompose sediment records into provenance and transport-related components. Our approach is fully consistent with the principles of compositional data analysis which also ensures its statistical tractability.

TRACE FOSSILS RECORDING ENVIRONMENTAL DYNAMICS OF HOLOCENE ESTUARINE INCISED-VALLEY FILL DEPOSITS (RED RIVER, GULF OF TONKIN)

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The Gulf of Tonkin coastline migrated at an average rate of 60 m/yr landward during Holocene sea-level rise (20-8 ka). Due to a combination of rapid coastline migration and undersupply of sand neither coastal barriers nor tidal sand bars developed at the mouth of the Red River incised valley. Thus, the river mouth represented a mud-dominated open funnel-shaped estuary during transgression. The Holocene muddy infill of the incised valley of the Red River documents a change of the depositional setting from fluvial, to estuarine and finally marine conditions. The open funnel-shaped river mouth favored upstream incursion of seawater that varied inversely to the seasonal strongly fluctuating discharge: several centimeters to a few tens of centimeters thick intervals showing marine or freshwater dominance alternate. Trace fossils provide information about a highly dynamic depositional processes, which are otherwise not recorded. Recurrent short-term seawater incursions stressed the burrowing fauna. The degree of bioturbation increases upward corresponding to increasing marine influence. The uppermost estuarine sediments are completely bioturbated. Siphonichnidal burrows produced by bivalves occur in estuarine sediments experiencing some marine influence as suggested by geochemical proxies. Within these deposits, the producers of Siphonichnus moved several tens of centimeters upand downward. They document a highly dynamic depositional setting. Although the Holocene sediments aggraded in average at a high rate (> 1 m/kyr), severe erosional events must have occurred because the Siphonichnus producers burrowed downward for in maximum 1 m. Also the fill of Siphonichnus burrows points to erosion and bypass of sediment. Siphonichnus burrows were produced in muddy sediment, but (parts of) the burrows are filled with sand that is otherwise not found in the sediment record. Obviously, the sand was present when the Siphonichnus producers fed from the sediment surface, but it has been eroded later. In an estuarine setting erosional processes may occur when river runoff and ebb-tidal currents interact within the backwater limit. Furthermore, during onset of the freshet (= high flood period) the river is in an erosive stage. As freshet proceeds the river shifts from erosion and sediment bypass to deposition.

CONTROLS ON SPATIAL FACIES VARIATIONS IN SUBMARINE CANYON COLD-WATER CORAL HABITATS

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Cold-water corals form extensive habitats in the upper reaches and rim of the Porcupine Bank Canyon on the Irish Margin, NE Atlantic. ROV-based multibeam and video inspections and transects reveal variation in cold-water coral facies in response to local scale submarine canyon process controls. Corals are depth zonated with respect to water mass properties but also show significant variation laterally along the canyon. Calcareous framework builders are dominant although antipatharians and gorgonions also support significant communities. As well as sedimentary facies and exposed, sometimes vertical rock habitats, coral facies includes carbonate mounds, coral coppices, isolated opportunistic colonises and extensive seafloor blanketing by coral cover (or coral gardens). The stature, bioerosion balance, density and species associations with the coral habitats vary within the canyon both vertically, with respect to slope gradient. Some areas show evidence of coral recolonization possibly after episodic destructive events. Buried hardgrounds in the canyon point to a dynamic and episodically eventful canyon environment. A quantitative approach to coral facies mapping is presented to parameterise coral facies variations to canyon processes controls. Temporal changes in the coral habitat have been parameterised from coral and coral-sedimentary archives.

CONSTANT SEAWATER TEMPERATURE AND SALINITY VARIATIONS AT THE MIDDLE–LATE JURASSIC TRANSITION IN SUBBOREAL BASINS: INSIGHTS FROM CLUMPED ISOTOPE ANALYSES

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Published oxygen isotope studies point to a prolonged (Late Callovian–Middle Oxfordian) period of the presence of cold (5–8.5°C) bottom waters in the epicontinental Middle Russian Sea, belonging to the Subboreal province, followed by a pronounced Late Oxfordian–Late Kimmeridgian warming of 6.5–9.5°C. The incursion of cold bottom waters during the Late Callovian–Middle Oxfordian was interpreted as a result of the establishing of wide marine connections between the Middle Russian and the Arctic seas under a sealevel highstand. Coeval but shorter cooling events are also reported from the Western Europe and sometimes regarded as manifestation of cold snaps in the Jurassic climate. The Late Oxfordian–Late Kimmeridgian warming may, however, be overestimated due to local salinity effects on seawater $\delta^{18}O$ values. As an independent proxy for palaeotemperatures, clumped isotope data may allow estimation of the extent to which the $\delta^{18}O$ record is affected by local salinity variations.

Good preservation state of studied shell material from the Russian Platform is evidenced by the lack of cathodoluminescence of calcite fossils, their low Mn and Fe and high Sr concentrations, the preservation of metastable aragonite, and the original microstructure of ammonite shells as well as low thermal maturity of the organic matter present in sediments. Clumped isotope analyses were performed on a set of 20 well-preserved belemnite rostra and 4 ammonite shells derived from the uppermost Middle–Upper Jurassic (uppermost Callovian–lowermost Upper Kimmeridgian) of the Russian Platform. At least 5 replicates were run for each sample. Samples were digested at 90°C in a common acid bath connected to a fully-automated device for cryogenic purification and GC cleaning of CO_2 gas. Analysed gas was measured on a Thermo Scientific MAT 253. D47, raw data correction comprised the application of a background correction scheme and the direct projection to the absolute scale. The calcium carbonate temperature equation of Wacker et al. 2014: (1) $\Delta47 = 0.0327(\pm0.0026)*106/T2 + 0.3030(\pm0.0308)$ where $\Delta47$ is given in per mille, and T in K, was used for water temperature calculations. Salinity reconstructions are based on the accepted oxygen isotope fractionation between calcite and water and available palaeosalinity models.

Clumped isotope analyses suggest constant bottom water temperatures (~15°C) of the Middle Russian Sea during the latest Callovian–earliest Late Kimmeridgian. This questions the previous interpretation of the fossil $\delta^{18}O$ record. The Upper Oxfordian–Lower Kimmeridgian decrease in $\delta^{18}O$ values, which was previously explained by warming, probably results from a decrease in salinity of ~10 PSU. A decrease in sea level after the Middle–Late Jurassic transition transgression could have contributed to the enhanced freshwater runoff, and the limitation of oceanic water exchange with the restricted Middle Russian Sea. This probably led to the significant decrease in salinity and water $\delta^{18}O$ values.

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DOES THE THICKENING OF ILLITE CRYSTALS CONTROL THE FORMATION OF SECONDARY POROSITY IN OILFIELD SANDSTONES?

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Secondary porosity is a common feature in oilfield sandstones, with controversy over the mobility of aluminium and hence whether the porosity is effective, i.e. a genuine increase, or balanced by the precipitation of clay or other minerals. In the Jurassic Fulmar sandstone of the UK North Sea, secondary porosity is abundant, but clear authigenic clay is rare – leading to the proposal that the products of feldspar dissolution (including aluminium) must have been exported from the sands. Yet whole-rock chemical data fail to show the expected export – so where has the Al gone?

It has previously been reported that, in authigenic illite separated from oilfield sandstones, both the potassium content and the crystal thickness increase with increasing burial depths. Although there is little or no analytical data about how aluminium changes with depth, the structural formula for illite shows that, as potassium increases, so does aluminium (at the expense of silicon, to retain charge balance). Hence, the aluminium content of authigenic illite must increase with depth. This means that, either the illite continuously recrystallizes during burial, or that the amount of illite must increase (and the new illite is more K- and Al-rich than the older). The former idea, continuous recrystallization, would be expected to reset K-Ar ages, which are generally thought to be reliable indicators of theformation of illite, and this explanation can be rejected. Hence, new illite is forming during burial, which is consistent with the thickening of individual illite crystals (or fundamental particles as these are known).

It is hence proposed that aluminium from the dissolution of feldspar is taken up by the thickening of fundamental particles within grain-coating clays. This is perhaps because fundamental particle thickening does not involve the nucleation of new illite, and nucleation is a difficult process geologically that only seems to occur as events, for example during oil charging or during periods of rapid porewater flow.

As the products of feldspar dissolution are absorbed largely within clay coats, so the micro-porosity of these coats decreases, but the porosity of the pore network outside of the clay coats is enhanced by the addition of secondary porosity. The neo-formed illite within clay coats is virtually impossible to detect using standard petrographic techniques, resulting in an underestimate of the sinks for Al and K within the sandstone. Oil-staining and bitumen impregnation of clay coats in the example of the Fulmar Formation makes detection even more difficult.

In conclusion, the thickening of illite crystals within grain-rimming clays by Kand Al-rich material provides a sink that has been previously underestimated. The process is 'continuous' and not restricted to events, unlike the growth of new illite fibres which might bridge pore spaces and cause massive permeability loss.

THE FOUNDERING OF CARBONATE PLATFORMS: THEIR SEDIMENTARY AND GEOCHEMICAL SIGNATURES

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Carbonates build amongst the largest edifices on the planet, are able to keep-up with most tectonic or glacio-eustatic induced sea-level rises and consequently the foundering of many platforms is often enigmatic. The cause of demise of platforms and the deposition of potential overlying seal units are critical for understanding thresholds for carbonate platform survival as well as petroleum systems evaluations in better understanding relationships between reservoirs and caprocks. The paradox of foundering of carbonate platforms has been variously linked to 'drowning' via (1) fast glacio-eustatic sea-level rise, (2) tectonic induced sea-level rise (3) nutrient and/or clastic poisoning and (4) subaerial exposure, shut-down of the carbonate factory and a subsequent inability to 'catch-up' on subsequent reflooding. Despite, better understanding of the foundering of carbonate platforms being critical for their survival evaluations of the sedimentary, geochemical and petrophysical signatures of each of the potential causes for demise remain understudied. This study will evaluate the sedimentary, geochemical and diagenetic signatures across key outcrop analogue sections and subsurface reservoirs to understand the impacts of different causes of foundering on reservoir and caprock development. The work to will investigate a: (1) transgressive drowning succession of an isolated platform, (2) nutrient influenced land-attached platform with carbonate foundering, (3) a carbonate buildup affected by karstification prior to drowning, and (4) a volcanogenic smothered system.

QUANTITATIVE 3D SEISMIC STRATIGRAPHY AND GEOMORPHOLOGY: APPLICATIONS FOR HIGH-RESOLUTION STRATIGRAPHIC STUDIES AND GEOLOGICAL MODELLING OF THE CENOZOIC SEQUENCES ON AUSTRALIA'S NORTH-WEST SHELF

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Modern seismic acquisition and data processing technologies have resulted in an abundance of data available for geoscientists. Determining how to process and interpret such datasets in an efficient and accurate manner is an ongoing problem in contemporary geoscience. Traditional seismic stratigraphy workflows have often required large trade-offs between speed, scope, and resolution, potentially resulting in large swathes of neglected data. However, recent advancements in full-volume 3D seismic interpretation methods have enabled the development of new workflows for high precision regional 3D seismic stratigraphy.

Here, using a 7500 km^2 3D seismic volume we perform high-resolution seismic stratigraphy over the carbonate dominated Cenozoic interval of the Northern Carnarvon Basin (NCB), Australia. Utilising full-volume semi-automated horizon tracking and a relative geological time (RGT) model computed throughout the 3D seismic dataset, chronostratigraphic surfaces extracted at a very high density allow very high-resolution stratigraphic analysis. Age control was provided by detailed biostratigraphy and Strontium isotope dating of well samples. Seismic attributes calculated on these surfaces allowed determination of depositional processes and environments through 3D seismic geomorphology. Surfaces and geobodies extracted through this process were also used to build a data constrained complex 3D geological model of the area. This model helped identifying areas of complex lithological and petrophysicalproperties that negatively impact seismic imaging. Quantitative data relating to clinoform geometries (height, slope angle, set thickness), were measured and used to calculate key stratigraphic parameters such as rates of progradation, aggradation, and sediment partioning rates from shelf to basin.

Integration of this data provides new insight into the impact of changes in accommodation space (eustasy and subsidence-driven), sediment supply and carbonate production throughout the Cenozoic in the NCB. In particular, how the interplay of such controls impact the nature of shelf and slope processes and the resulting distribution of shallow and deep water sedimentary deposits. This study utilises innovative new workflows developed recently to conduct seismic stratigraphy in 3D space, and represents a first case implementation of such workflows in a carbonate dominated setting.

INTERACTIONS BETWEEN REGULATION WORKS, OVERBANK SEDIMENT STRUCTURES AND CONTAMINATION ALONG THE RHÔNE RIVER CHANNEL

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To improve navigation and produce hydroelectricity on the Rhône river, the channel was regulated in the 19th and 20th centuries. It is now narrower and only conveys a minimum flow, most of the water flowing in a canal parallel to the by-passed former main channel. Such regulations have considerably altered the suspended sediment transfers, resulting in the storage of sediments contaminated by numerous anthropogenic substances within engineered margins (mainly groyne fields, groynes being linked one to each other by a continuous longitudinal infrastructure).

In the framework of restoring these engineered margins and the associated risk issues, it is important to estimate the volumes of contaminated sediments and their filling chronology. We investigated overbank sedimentation patterns and associated contamination in one of the by-passed reach of the Rhône, Péage-deRoussillon.

We present a method for characterizing overbank sediment structures and contamination using geophysical imaging (Ground Penetrating Radar or GPR; Electrical Resistivity Tomography or ERT), Lidar data and coring (multi-proxies approach, dating). 28 GPR and 4 ERT profiles were obtained and interpreted, representing a total length of respectively 6.4 and 1 km. Once the sedimentary units were identified using radar profiles, the coring locations were determined to group as many of these units as possible. Hence, six cores, whose depth was limited by the old bed of the Rhone composed of gravel and forming the wall of sediment fill since the development works of the 19th century, were taken and analyzed.

According to GPR imaging, different sediment structures and patterns were distinguished between engineered margins, late 19th c. disconnected channels and older floodplain. Changes in grain-size distribution in the cores were interpreted as indicating the effects of river regulation on sedimentation. Sediment cores XRF and chemical analysis allowed to distinguish different degrees of sediment contamination depending on the depositional environment and chronological reconstitution: significant contamination in engineered margins, from moderate to low in late 19th c. disconnected channels and low to no contamination in older floodplain. Finally, this study is a first step in establishing a conceptual model of anthropogenic effects on overbank sedimentation and the distribution of contaminants in depositional environments of rivers.

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EXPLORING THE GEOLOGICAL CONTROLS ON GROUNDWATER STORAGE AND DISCHARGE DYNAMICS IN THE SWISS ALPINE FORELAND

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Prolonged dry spells expected with climate change will affect water resources in the alpine foreland. It is therefore crucial to assess the sensitivity of watersheds to droughts and thus to investigate how hydrological, hydrogeological and physical parameters control the water-storage capacity and recharge-discharge dynamics. In this contribution, we focus on the role of the geology, i.e. the Molasse bedrock and the Quaternary deposits, during low-flow conditions in the Swiss alpine foreland.

Synthetic numerical models simulating coupled surface and subsurface flow processes show that the hydrogeological quality of the Molasse bedrock is the primary factor in controlling catchment dynamics. Hydraulic conductivity K and porosity P greatly control how water is stored and released during low-flow conditions. In contrast, the Quaternary unconsolidated valley fillings are less important during prolonged low-flow conditions as they deplete relatively fast due to their typically higher hydraulic conductivity as compared to the bedrock. In addition, they represent a substantially smaller storage volume than the bedrock.

Given the importance of the Molasse bedrock demonstrated by the synthetic models, we explored the variability of its hydrogeological quality in the Swiss alpine foreland. The approach is based on a simplified subdivision of the Molasse into four principal lithologies. The hydrogeological quality of these lithologies is assessed using typical K and P values from the literature. We established an overview map of the four lithologies based on available paleo-sedimentological concepts and geological maps. The 2D overview is complemented with approximate thickness maps of the classical Molasse units (Lower Freshwater Molasse USM, Upper Marine Molasse OMM, Upper Freshwater Molasse OSM). This provides us with depth information and thus allows us to calculate potential volumes of groundwater stored in the bedrock of a specific watershed. The attempt of incorporating the 3D geology seems particularly important as past similar studies often only used 2D geological information without considering changing lithology with depth.

In a thorough assessment of the sensitivity of a watershed to droughts, the hydrogeological quality of the Molasse will be combined with information on Quaternary aquifers, as well as with topographic and hydrological properties. This will allow us to anticipate the sensitivity of a watershed to droughts solely on its geological and topographic characteristics.

THE ORIGIN AND DISTRIBUTION OF CLAY COATED SAND GRAINS IN A HOLOCENE MARGINAL MARINE FILL SUCCESSION

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Clay coated sand grains (chlorite, illite and mixed mineralogy) have been shown, both in nature and laboratory-based studies, to inhibit the typical porosity-occluding authigenic silica cement and such, preserve elevated porosity in deeply buried sandstones. Thus, the ability to predict the distribution of claycoated sand grains is vital in exploiting anomalously good reservoir quality within deeply buried sandstone reservoirs.

This study adopted an analogue methodology, focused on the Ravenglass Estuary, UK. The work involved sedimentary and biological analysis of this Holocene to modern sedimentary system. Surface samples (300), shallow cores (26x1m), and longer cores (20x15m) (down to glacial till), developed a high resolution framework of the Holocene estuarine succession. A range of scanning electron microscopy, environmental scanning electron microscopy, and automated SEM-EDS mineralogy techniques, were used to characterise the distribution patterns of clay coated sand grains. Raman spectroscopy, chlorophyll-a (biomarker) and microbial carbohydrate analysis (GC-MS) were undertaken to constrain the biological origin of sediment biofilms on sand grain surfaces.

This unique framework of a complete Holocene estuarine succession has produced detailed maps of the spatial and stratigraphic distribution of clay coated sand grains, the heterogeneity of clay coat mineralogy, and sediment heterogeneity, which by analogy can be applied to help the prediction of clay-coated grains in the subsurface. This work has also identified a principal biological (biofilm) mechanism of clay coat formation and resolved the relatively limited geographical distribution of clay coat formation. The results of which have the potential to revolutionise the way the hydrocarbon industry understand the origin and distribution of clay coated sand grains within sandstones. The work has revealed for deeply buried prospects that, possibly against common convention, the best porosity may be found in fine-grained, clay-bearing inner estuary tidal flat and tidal bar facies sands.

PETROLEUM TYPE CONTROLS THE TEMPERATURE OF H_2S GENERATION BY THERMOCHEMICAL SULPHATE REDUCTION (TSR)

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Thermochemical sulphate reduction (TSR) involves the replacement of anhydrite ($CaSO_4$) by calcite ($CaCO_3$) in oil and gas reservoirs, when the sulphate mineral is chemically reduced by petroleum fluids. This seemingly innocuous process results in the generation of large quantities of H_2S that are toxic, corrosive and economically-detrimental in oil and gas fields. The influence of petroleum type (oil versus gas) on the minimum temperature at which TSR occurs has been examined from 12 wells in petroleum accumulations spread across the Permian Khuff Formation, covering a large area in eastern Saudi Arabia, using core, petrography and fluid inclusion studies. Fluid inclusion studies of the replacive calcite show that oil-induced TSR occurs at a significantly lower temperature (minimum 102°C, average 129°C) than gas-induced TSR (minimum 125°C, average 152°C). The different onset temperatures for the different types of hydrocarbon is probably the result of the fundamentally greater reactivity to anhydrite of oil phase compounds than gas phase compounds. This study has also revealed the effect of TSR on the salinity of the water that remain sin oil and gas fields. Salinity of aqueous inclusions trapped in TSR calcite decreases with increasing homogenization temperature showing that water must have been a by-product of TSR. Gas-induced TSR led to lower salinity inclusions than oil-induced TSR, indicating that relatively more diagenetic water is produced by gas-induced TSR than oil-TSR. TSR occurs via aqueous solution so that the creation of the reactive medium may exert an autocatalytic effect inevitably allowing more and faster TSR to occur as the reaction progresses. Knowing that TSR occurs at different temperatures as a function of petroleum phase will allow better prediction and modelling of the timing and extent of gas souring (H_2S generation) in deeply buried petroleum accumulations.

THE EFFECT OF OIL EMPLACEMENT ON QUARTZ CEMENTATION IN A DEEPLY BURIED SANDSTONE RESERVOIR

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Quartz is an important, porosity-occluding cement in sandstone reservoirs that have been subjected to elevated temperature for a substantial period of time. The effect of oil emplacement on quartz cementation in reservoir sandstones is controversial; some studies have concluded that early oil emplacement can inhibit quartz cementation leading to the preservation of porosity, while other studies have concluded that quartz cementation appears to be largely unaffected by oil emplacement. Here we have studied shallow marine, Upper Jurassic sandstones from Ula Field, Norwegian North Sea, with reservoir temperatures of about 150 °C, to determine whether oil emplacement had a significant impact on diagenesis. Following sedimentological description of cores, samples above and below the oil-water contact have been collected, adjacent to core analysis plug points. These samples then underwent a series of studies, including SEM-EDS (QEMSCAN) and point counting. These data were then integrated with routine core analysis and petrophysical log data. Density and resistivity log data were used to determine the precise oil saturation of each sample. The distributions of all potential controls on porosity and permeability, such as grain size, sorting, matrix clay content, degree of bioturbation, and the presence of grain coatings, as well as the amount of quartz cement, have been assessed. Primary oil inclusions within quartz cement shows that oil ingress into the Ula reservoir commenced prior to the onset of quartz cementation. Very fine-grained, matrix-rich, bioturbated and microquartz-cemented sandstones have uniformly low quartz cement contents irrespective of oil saturation. Medium-grained, graded, matrix-poor, microquartz-poor sandstones have quartz cement ranging from 1 % to greater than 17 %, associated with core porosities of about 22 % and 7 %, respectively. Higher oil saturations equate to higher porosities and permeabilities in the medium-grained, graded, matrix-poor, microquartz-poor sandstones, which cannot be explained by any control other than the amount of quartz cement as a function of pore fluid type. Oil emplacement therefore appears to have inhibited quartz cementation at high oil saturations and can be viewed as a significant control on reservoir quality. The significance of this study is that the presence of oil in a sandstone reservoir, at the time that quartz cement was growing, can have a considerable impact on reservoir quality. This work has proven that oil emplacement can definitely inhibit quartz cementation under some circumstances.

HALOGEN ELEMENTS IN SEDIMENTARY SYSTEMS AND THEIR EVOLUTION DURING DIAGENESIS

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The patterns of halogen concentration in sedimentary formation waters can be of great significance since they reveal much about the fluid flow history of a basin in general and oil or gas fields in particular. The full range of processes capable of influencing halogen concentrations in sediments, sedimentary rocks, and formation waters and other fluids involved in diagenetic reactions have been investigated. Chloride and Brare typically assumed to be conservative in sedimentary and diagenetic systems since they are considered to be independent of silicate, carbonate, sulphate, sulphide, or oxide diagenetic processes. Chloride distribution in sedimentary systems is controlled by: variable degrees of seawater evaporation; seawater dilution by meteoric water flushed through the sediment pile, freshwater evaporation in arid continental basins; seawater freezing; evaporite dissolution; seawater concentration by silicate diagenetic hydration reactions in the sediment column; seawater dilution by diagenetically-produced water associated with overpressure build-up; and membrane filtration through low permeability rocks. There are circumstances under which Br may not be a conservative element when compared to Cl. These include hydration reactions, which may preferentially remove Brand Cl from water; evaporative concentration, which may lead to loss of Br^- by atmospheric ozonation processes; incongruent dissolution of Br-poor halite; dissolution of Br-enriched potash facies evaporites; breakdown of Br-bearing organic matter; or retarded membrane filtration of Br compared to Cl. Water geochemical data from oil and gas fields have here been collated and compared with a range of likely controlling processes. Chloride and Brconcentrations in formation water are enormously variable with the most important controls being dilution of seawater by meteoric water; evaporative concentration (of seawater or continental waters); dissolution of haliteand/or potash-bearing evaporites; diagenetic hydration reactions; and diagenetic dehydration reactions. Dissolution of mixed halite-potash facies evaporites by meteoric water can explain the large range of Cl/Br ratios found in formation waters. High Brconcentrations in deeply buried formation waters are typically assumed to represent the residue of extreme evaporation of seawater although, as shown here, they can also be the result of the dissolution of Br-enriched, potash-bearing evaporites. Fluoride is non-conservative in formation waters and its concentrations are typically low since this element is incorporated in minerals, following alteration and diagenesis, such as fluorite, apatite, and clay minerals. Iodide is also non-conservative and is found at relatively high concentrations in some formation waters due to the breakdown of I-enriched and organic-bearing sedimentary rocks. The specific patterns of halogen concentration in sedimentary oil and gas field formation waters can be of great use as they reveal details of the origin and evolution of the sedimentary succession.

CYCLOSTRATIGRAPHY IN THE HAUTERIVIAN-BARREMIAN FRIELINGEN CORE (LOWER SAXONY BASIN, GERMANY)

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Astrochronology has proven to be a powerful method to constrain the duration of geological periods. However, in some geological periods, cyclostratigraphic studies give diverging results. For instance, the duration of the Hauterivian Stage was estimated as 3.5 myr in central Italy, and 5.9± 0.4 myr in South-Eastern France and South-Eastern Spain. In the Lower Saxony Basin, pale marl-dark shales cycles in Hauterivian and Barremian sediments are accompanied by changes in clay mineralogy, floral and faunal communities and geochemistry (variations in Ba, Si, Ca, Rb, Fe and Zr), which point to orbitally-forced climatic cycles. High-resolution (1 cm) scanning XRF results have been recently acquired on the Frielingen core which is situated next to Hannover (Germany) and encompasses the Hauterivian. On these geochemical data, time-series analyses will be performed to identify the orbital imprint on the alternations. This signal will then be used to give new insights on the duration of the Hauterivian.

DISTRIBUTION AND EROSION OF THE MESOZOIC TECTONIC UNCONFORMITIES IN KUQA-TABEI AREA, THE TARIM BASIN, NORTHWEST CHINA: SIGNIFICANCE FOR THE EVOLUTION OF PALEO-UPLIFTS AND TECTONIC SETTING DURING DEFORMATION

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Distribution and erosional features of the Mesozoic major tectonic unconformities in Kuqa-Tabei area of the Tarim Basin, and their genetic relation to the evolution of Paleo-uplifts as well as the geodynamic settings, are documented in this paper based on the integral analysis of seismic, drilling, and core data. During the Mesozoic, the study area underwent 4 major tectonic deformation stages, resulting in 4 regional angular unconformities (TT, TJ, TK and TE) and 1 parallel unconformity (TK1bs). According to those unconformities, the Mesozoic is divided into 4 second-order sequences corresponding to Triassic, Jurassic, latter Cretaceous Kapushaliang Group and latter Cretaceous Bashijiqike Formation. Unconformity TT was the product of the End-Permian tectonic deformation with maximum erosion thickness of 1000 m including Permian, Devonian, Silurian and Ordovician at uplift high of Paleouplifts. Unconformity TJ, resulted from the End-Triassic tectonic uplift, was mainly distributed over the Wensu, Xiqiu, Xinhe and Yaha Paleo-uplifts with general denudation thickness of 300 m. Another deformation took place at the end of Jurassic and generated unconformity TK. Banding denudation belts of unconformity TK were distributed mainly along the thrust structural highs. Unconformity TE was resulted by the tectonic deformation occurring at the end of the lower Cretaceous Bashijiqike Formation, erosion belts of which were distributed mainly along the Wensu Paleo-uplift with maximum erosion thickness of 200 m. Distribution range of Wensu, Xiqiu, Xinhe and Yaha Paleo-uplifts in the study area enlarged apparently during latest Triassic-earliest Jurassic. But then, as a whole, the distribution range decreased due to the onlap fill of Jurassic as well as Cretaceous and even disappeared at the end of the lower Cretaceous Kapushaliang Group excepting the Wensu Paleo-uplift with continuing exposure and erosion. Comparative analysis of uplifting with regional tectonic setting indicates that deformation taking place during the 4 periods was related to the evolution of Mesozoic plates and orogenesis around the basin. During the Late Hercynian Movement occurring at the end of Permian, the collision and suturing of Tarim Block, Ili-Central Tianshan and Siberia plate as well as respective rising of Tianshan Mountain and Kulun Mountain in northern and southern side of the basin contributed to the uplifting of Pre-Triassic and the formation of unconformity TT. During the Indosinian Movement occurring at the end of Triassic, collision and suturing between Qiangtang Block and Tarim Plate occurred. Kunlun Mountain orogenic zone rose abruptly and large-scale A-subduction occurred in mountain front. The culminated S-N trending compressive stress resulted in rapid uplifting of Tabei Uplift and extensive development of unconformity TJ. The Late Yanshan Movement took place in latest Jurassic. With the southing compression of Siberian Plate, the northwards collision and suturing of Lasa Block, Qiangtang Block, Eurasia and Himalayan Terrain occurred. Regional extrusion stress resulted in tectonic uplifting and development of unconformity TK. The early Himalayan Movement occurred in the late Cretaceous. South Tianshan Mountain uplifted dramatically and finally obducted into the northern margin of Tarim Plate. Under the tectonic compression, integral uplift occurred and unconformity TE developed.

SOURCE TO SINK EVOLUTION OF NON-MARINE RIFT BASIN DRIVEN BY TECTONIC FORCING: INSIGHT FROM COUPLED TECTONIC-STRATIGRAPHIC NUMERICAL MODEL AND DONGPU SAGOF BOHAI BAY BASIN

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The climate and tectonic signal control on the landscape and depositional sequence evolution of the basin are important subjects in study of source to sink analysis. Unlike marine basin with relatively stable tectonic subsidence, the rift basins have undergone complex and varied tectonic evolution. Tectonic is the main driving force for the formation of accommodation and plays an important role in the evolution of rift basins.

In this study, coupled 3d tectonic-stratigraphic model is used to reconstruct the source to sink evolution of rift basins which are controlled by different tectonic forcing. And the model has been through two continuous evolution stages from the alluvial basin to lacustrine basin, with presumed constant lake level and rain fall under stable climate condition. According to the model, we detailly discuss the controls of tectonic on the evolution of landscape and depositional sequence.

In the evolution stage of the alluvial basin which can be regard as the periods of early syn-rift to the rift climax. During this stage, most of the sags are filled by the long-axial direction rivers and transverse direction alluvial fans which are controlled by the geomorphic units consisting of synthetic approaching transfer zone, strike ramp, fault terrace and gully. Specifically, the sediment entry point is controlled by the location of the transfer zone and gully. Transverse source systems converge to the long axial river systems, filling the sags. The strata pattern of depositional sequence is both controlled by the temporal-spatial distribution of high tectonic subsidence rate zone HTSRZ and pattern of river systems. When the subsidence rate is symmetrically distributed within the sags, alternated strata of sandstone and mudstone are formed. With the HTSRZ shifting to the edge of sags, wedge-shaped strata patterns are formed and the strata pattern of general slope show onlap characters. Generally, the thickness of coarse grained deposits is relatively thin, which is not limited to the edges, but distributed within the entire sags.

In the evolution stage of the lacustrine basin which can be regard as the periods of rift climax to the late syn-rift stages. The depositional system transformed into the fan delta, subaqueous fan and lacustrine systems. During this stage, the most of sedimentation provenance is sourced from the edges of the sags. The strata pattern of depositional sequence is controlled by the relatively steep relations between the two sides of boundary faults. Specifically, when the sags show symmetrical geometry, the strata pattern shows bidirectional filling character. However, if the sags show asymmetrical geometry, the strata pattern changes into the unidirectional filling character. Generally, the thickness of coarse grained deposits is relatively thick and limited to the edges, forming typical downlap or offlap strata.

A comparison of the model result with the 3D seismic data of Dongpu sags in Bohai Bay Basin shows many common geometrical featureswhich indicates that tectonic can be treated as an independent controlling factor in producing a similar result to the multiple factors controlled real case.

GEOMORPHOLOGY AND QUATERNARY SEDIMENTARY CHARACTERISTICS AROUND LARGE ISOLATED CARBONATE PLATFORMS IN XISHA (PARACEL) ARCHIPELAGO, SOUTH CHINA SEA

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New high-quality multi-beam and seismic dataset imaged the slope of the Xisha (Paracel) archipelago and reveals bypass areas, gullies, moats, canyons, deep-water channels, and products of slope instabilities, including slumps and mass transport deposits (MTDs) surround the Xisha atolls. These different geomorphologic units combine together in space and extend seaward into the pelagic plain. The gullies, canyons and deepwater channels incised by peri-atoll gravity flow, are passages for the export of large volumes of sediments into the far-off ocean basin. They are connected with each other and stretch hundreds of kilometers seaward down the slope. The scattered atolls are buildups of neritic carbonates that are mainly composed of coral reefs and calcareous shells of foraminifer and echinoderm. Seismic data reveal Xisha archipelago is a source to produce carbonate sediment and volcanic rock detritus by margin shedding. Furthermore, moats around the atolls associated with drifts along the peri-atoll slope verify is the flow of strong bottom currents through the inter-atolls slope in the Xisha area. Erosion by bottom currents of the slope promotes to trigger gravity flow by increasing the slope instability. This study reveals that neritic atolls can affect the sedimentary process in deep-sea basin by peri-atoll gully-canyon-channel systems.

CLASSIFICATION AND FACIES SEQUENCE MODEL OF SUBAQUEOUS DEBRIS FLOWS

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Debris flows are cohesive sediment gravity flows which occur in both subaerial and subaqueous settings. Compared to subaerial debris flows which have been well studied as a geological hazard, subaqueous debris flows showing complicated sediment composition and sedimentary processes were poorly understood. About 3000 m cores from the Paleogene Dongying depression of Bohai Bay Basin were observed in this study. Large-scale measurements of four field profiles (1:20) from the late Triassic Ordos Basin and analyses of thin section and laser-diffraction particle size of 798 samples were also performed. Three types of subaqueous debris flows were identified based on particle sizes and sediment support mechanism, i.e., sandy debris flows, muddy debris flows and mud flows. Sandy debris flow primarily comprises sandsized particles with few mudand gravel-sized particles. They are supported by matrix strength, dispersive pressure and buoyancy. Sandy debris flows are commonly non-viscous, have relatively high yield strengths. Individual events of which are usually thick, ranging mainly from 30 to 300 cm, and are commonly shown as very clean sandstone or clean sandstone with floating uniform-composition clasts. Sediments in a muddy debris flow are a mixture of mud-, sandand gravelsized particles, and the sediments are primarily supported by matrix strength. They are cohesive, and have high yield strengths. Deposits of a single muddy debris flow are extremely thick up to dozens of meters with much floating gravel with complex compositions. In a mud flow, the sediments comprise of more than 80% of fine siltand mud-sized particles and varying amount of gravel-sized particles. The gravels are commonly intraclasts of rip-up clays or silty clays; extraclasts are also common. A mud flow typically has low yield stress, and is semi-cohesive. Depositional thickness of which varies from very thin to very thick. Ideal subaqueous debris flow is composed of mud-rich pseudo-parallel division (Da), plug flow massive division (Db) and clast-rich inverse graded division (Dc) from bottom to top. Da resulted from slowing-down deposition due to bed friction and roughly directional alignment of internal muddy or sandy clasts (pseudo-parallel bedding) because of high viscosity of debris flow. Db was formed by mass transportation and freezing sedimentation in plug flow with a uniform velocity. Dc was generally muddy due to decreasing velocity by stronger friction of overlyingwater. It was possibly rich in clasts resulted from clasts rising under vibratory shaking of grains and clasts, and characterized by inverse grading. However, the composition of facies sequence of subaqueous debris flow may be changed with sediment composition, sediment concentration and transporting-depositing processes. Subaqueous debris flow can be divided into three types according to forming conditions and genetic processes: (1) slump-style subaqueous debris flow caused by subaqueous slope failure; (2) inherited subaqueous debris flow derived from subaerial debris flow, pyroclastic flow or subaqueous eruptions; (3) transformed subaqueous debris flow caused by underwater flow transformation from turbidity current to debris flow.

THE GEOCHEMICAL RESPONSES OF DIAGENESIS AND ACCUMULATION IN THE NATURAL GAS HYDRATE OCCURRENCES AT SH7B STATION IN SHENHU AREA, SOUTH CHINA SEA

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This paper carries out a series of geochemical detection on the sediment samples collected from SH7B Station in Shenhu Area, South China Sea. The organic and inorganic geochemical indicators, including acidolytical hydrocarbon, carbonate content, C and O isotopes, S contents and Glycerol Dialkyl Glycerol Tetraethers (GDGTs), are used to make a comprehensive study on the geochemical responses of diagenesis which is significantly affected by gas, solid sediments and microorganism in the hydrate system. Our results show that:

(1) In and above Gas Hydrate Zone(GHZ) of hydrate layer, acidolytical hydrocarbon methane, carbonate contents and sulfur contents are predominately higher, indicating a sedimentary and diagenetic response when AOM or sulfate reduction took place.

(2) In GHZ of hydrate layer, carbonate minerals show relatively lower $\delta^{13}C$ and negative-skewed $\delta^{18}O$ values.

(3) The distribution patterns of higher content of branched chain GDGTs and lower content isoprenoids GDGTs in GHZ of hydrate layer are consistent with the increase of terrestrial materials input, such as sandstone and silty deposits. The enriched methane fund in the hydrate layer is not autochthonous, so if the AOM is active, more anaerobic methanotrophic archaea (isoprenoid GDGTs) would result in more consumption of the methane, which is not conducive to the enrich of the methane.

According to the above results, we also propose that samples in the deeper part of the sedimentary sequence might reflect the completely diagenetic evolution of gas hydrate system. These can be inferred from the change of the hydrocarbon fluid (acidolysis hydrocarbon), microbial (GDGTs), solid sediments (carbonate and sulfur contents) as well as hydrate generation evolution. The significant AOM process, as one of the essential factors controlling the hydrate accumulation, is probably resulting in the formation of carbonate cements and authigenic mineral layer, which plays an important role in high pressure sealing and accumulation of the methane.

GRAVITY FLOW SEDIMENTARY CHARACTERISTICS AND THE SIGNIFICANCE OF PETROLEUM EXPLORATION OF TENGGEER FORMATION, BAIYINCHAGAN SAG, CHINA

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Based on observation of cores and thin sections and analysis of drilling, logging and test data, the characteristics of lacustrine gravity flow deposits of the TengGeer Formation are systematically analyzed. It is considered that the gentle slope in the eastern sag develops large braided river delta sedimentary system, its leading edge on the slope-break zone near the deep lake area is the favorable area of gravity flows which affected by multi-source supply, slope break, different trigger mechanism and fluctuation of lake level.

The main type of gravity flow deposits in the study area include sturbidite sand debris flow deposits, associated with the development of slump deposits as well. The sedimentary sequence of gravity flow is similar to the binary structure of fluvial sediments, it mainly develops "lentoid", thinner and thinner upward sedimentary sequence. Combined with deep-water autochthonous deposits, there are three different vertical sequences as follows: the mudstone-turbidity current deposits, the debris flow turbidity current deposits and the mudstone-debris flow deposits. Core observation shows that there are some incomplete Bouma sequences, various collapse and deformation structures. The grading curve with cluster sampling in an interval of 20 cm shows that the single-period gravity flow deposits in the early sedimentary stage appears convex arc and changes to the two-phase form in the late sedimentary stage. Which reflects a conversion process that the gravity flow transformed to traction current deposits as its energy changing from strong to weak.

Generally, the shape of SP curve of turbidity current deposits often appears bell-shaped, and debris flow deposists assumes boxlike and funnel-shaped. On the seismic profile, it appears mound-shaped.

The gravity flow deposits in study area distributed differently, according to the distance of the provenance and the lake level fluctuation. It is widely distributed in lowstand system tract (LST), which is mainly distributed in the gentle slope and migrated with the lake level oscillations. In highstand system tract (HST), its distribution is relatively limited and mainly distributed in relatively high position of the slope area. Multistage and multi-level gravity flow deposits cause lake area bound of sandstone and mudstone where the wide spread reservoirs and high quality source rocks contact closely vertically, forming multiple sets of sourcereservoir-seal assemblages.

Oil and gas exploration results show that the reservoir property of the gravity flow deposits is generally good, and there are exploration breakthrough, demonstrated a good exploration prospects. Gravity flow deposits exploration in Baiyinchagan sag is still in the exploratory stage, its study lays a solid foundation in looking for new favorable exploration targets in large lacustrine basin and has a role in promoting gravity flow sedimentary research.

DEPOSITIONAL CHARACTERISTICS OF THE SECOND MEMBER OF THE SHAHEJIE FORMATION IN THE EAST SLOPE OF GUDAO UPLIFT

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In recent years, many reservoirs have been found in the Paleogene stratum of the east slope of Gudao uplift,which showed a great exploration potential. But because of the geological conditions recognition and exploration degree is low, we need to strengthen the study of basic geology and hydrocarbon accumulation. Through the studying of the sedimentary environment and the sedimentary evolution characteristics of the research area, combined with the study of core analysis, particle size characteristics and electric characteristics, the results show that the braided river delta developed in the second member of the Shahejie Formation. The main features of the braided river delta were as follows: lithology was mainly pebbly sandstone, sandstone, fine sandstone and siltstone; the probability cumulative curves of grain size and the C–M diagram were mainly characterized by traction current sedimentary mechanism; the main colors of the mudstone were brownish red and fuchsia; sediment structures such as scour surface, wedge-shaped cross bedding and trough cross bedding were formed in high energy environment; the braided river deltaic body can be further separated into braided river delta front subfacies and pre-braided river delta subfacies,there is no braided river delta plain subfacies in the research area. The braided river delta front subfacies could be further separated into 4 sedimentary microfacies: subaqueous distributary channel, subaqueous inter-distributary channel, mouth bar and sheet bar. Using gamma ray log and self-potential as the identification of logging facies. The curve of subaqueous distributary channel is low box and campaniform; the curve of subaqueous inter-distributary channel is digitiform and serrateform; the curve of mouth bar is low infundibular; the curve of sheet bar is low digitiform. And we proposed a braided river delta model for research area, which is helpful for future oil and gas production and exploration.

PROVENANCE OF THE LAST GLACIAL SEDIMENTARY ORGANIC MATTERS FROM THE NORTHEASTERN SOUTH CHINA SEA AND ITS PALEOENVIRONMENTAL INDICATIONS

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South China Sea (SCS), located between the Asia landmass and the West Pacific, is one of the largest marginal seas in the world. As a part of SCS, the northeastern SCS is surrounded by southern mainland China, Taiwan Island and Luzon arc and connected to the East China Sea and Pacific Ocean by the Taiwan Strait and Luzon strait in the east. Because of its location and continuous high sedimentation rates, the northeastern SCS provides an ideal area for high-resolution studies of paleoenvironmental and paleoceanographic changes. In order to provide clues for provenance of sediments and short-term paleoclimate and paleoenvironment changes on the northeastern SCS. A total of 849 core samples collected from two drilling core STD235 and ZSQD289 in the northeastern South China Sea were analyzed for elemental composition including total organic carbon (TOC), total nitrogen (TN), stable carbon and nitrogen isotopic composition ($\delta^{13}C$, $\delta^{15}N$), and clay mineral composition. Based on clay mineral assemblages and organic geochemistry characters, it is supposed that the terrestrial source for sediments at STD235 and ZSQD289 is mainly from southwestern Taiwan. Moreover, the sedimentary organic matter of site ZSQD289 was probably directly inputted from southwestern Taiwan submarine canyon, while the sedimentary organic matter of core STD235 was probably transported by deep water current. The chronology suggested that it covered the record since ~19.7 and 34.6 ka BP in site STD235 and ZSQD289 respectively. Before the Last Glacial Maximum (LGM), high TOC/TN ratios with low $\delta^{13}C$ and $\delta^{15}N$ values might indicate that terrestrial organic input and nitrogen fixation was enhanced. During the LGM, gradually increased TOC, TN, $\delta^{13}C$ and $\delta^{15}N$ values might result from the enhanced burial of organic carbon and higher marine primary production constrained by the strong winter monsoon. TOC/TN ratios and $\delta^{13}C$ values generally present a decreased trend from LGM to Holocene (1811 cal ka BP), strongly correlated to the terrestrial organic input and marine primary production reduced during this period. Since Holocene, the terrestrial organic input to both sites further reduced and maintained a low level, in according with a high sea level and a gradual intensified summer monsoon.

CONTROLS ON DIAGENETIC PATTERNS OF GLACIOMARINE SANDSTONES IN CAPE ROBERTS PROJECT DRILLCORES: IMPLICATIONS FOR CENOZOIC CLIMATE, BURIAL, TECTONIC, AND HYDROLOGIC HISTORY OF VICTORIA LAND BASIN, ANTARCTICA

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The diagenesis of sedimentary rocks is fundamentally controlled by inter-related parameters, ranging from tectonic settings to depositional facies and palaeoclimatic conditions, but is less well understood in glaciogenic siliciclastic deposits. Cores recovered by the Cape Roberts Project (CRP) in the Victoria Land Basin (VLB), Antarctica, provide an excellent opportunity to assess diagenetic patterns and subsurface fluid history in glaciomarine sandstones within a well-established context of stratigraphy, sedimentology and basin tectonics. The CRP cores recovered a nearly complete stratigraphic transect through c. 1500 m of dipping strata extending from Lowermost Oligocene through Lower Miocene. The sedimentary record coincides with the VLB evolution from Oligocene basin rift phases to Miocene thermal subsidence phase, and also reflects dynamic behaviors of Antarctica ice sheet with attendant relative sea-level changes.

Sandstones sampled from CRP cores were examined by a mix of standard petrographic methods and geochemical proxies. The sandstones have undergone modest compaction showing mostly point-to-point grain contacts with primary porosities higher than 40%. Petrographic evidence, combined with measured geothermal gradient and estimated burial depth, indicates that diagenesis of CRP sandstones occurred in the eogenetic realm where diagenetic fluids were derived from surface or modified surface fluids. Cross-cutting relationships of diagenetic features revealed a range of diagenetic features, including near-surface pyrite framboids, pore-lining cubic and bladed zeolite cement, to low temperature burial fibrous smectite coatings, and alteration and dissolution of labile framework grains, such as feldspars, volcanic rock fragments and other ferromagnesian minerals. Secondary carbonates (low-Mg calcite and ankerite) are the predominant diagenetic products throughout burial, occurring as early-stage, microgranular cementation and recrystallization phases, and abundant late-stage, pore and fracture-filling, blocky/drusy and poikilotopic cements during or after alteration and dissolution of labile grains, leading to porosities approaching 0%. Stable oxygen isotopes of the diagenetic carbonates in CRP cores are depleted in ^{18}O, suggesting direct precipitation from ^{18}O-depleted cryogenic brine, which was discovered in pore water analysis during recovery of the Antarctic Drilling Southern McMurdo Sound core in the VLB. The brine was suggested to form as a result of progressive freezing of seawater along margins of advancing ice sheets as cold polar Antarctica climate regime was established in the Miocene.

This study suggests that fundamental controls on diagenetic patterns of glaciomarine deposits are complex and varied. The effects of climate, glacial processes and basin evolution on sedimentary processes and stratigraphic stacking patterns affect porosity distribution, as do burial history and the presence of potentially unique subsurface fluids in similar settings in the geological record. Future work will incorporate clumped isotope analysis of the diagenetic carbonates to better develop a robust diagenetic history and fingerprint critical timing of brine formation in the VLB.

REGIONAL DISTRIBUTION OF CRYOGENIC BRINE IN THE VICTORIA LAND BASIN, ANTARCTICA: IMPLICATIONS FOR ANTARCTICA CENOZOIC CLIMATE EVOLUTION AND GLACIAL PROCESSES

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Cryogenic brine, known as a byproduct of progressive seawater freezing, was discovered in pore water analysis during drilling of Antarctic Drilling (ANDRILL) Southern McMurdo Sound (SMS) program in the Victoria Land Basin (VLB), Antarctica. Geochemical analysis of abundant diagenetic carbonates in the sediments of the ANDRILL SMS drillcore indicated the brine as an important diagenetic fluid. The mechanism for brine generation involves sea ice formation producing dense brines in troughs formed due to ice sheet advance and glacioisostatic depression along continental margins. Therefore, the brine could have potentially infiltrated and extended regionally, leading to widespread carbonate cementation in the subsurface of the VLB, during repeated glacial advance and retreat cycles. This work investigates diagenetic patterns in complete, chronostratigraphically and sedimentologically well-constrained stratigraphic sections distributed in the VLB to understand the origin and spatiotemporal distribution of subsurface fluids with respect to palaeoclimate evolution in the VLB. A mix of standard petrographic methods and geochemical proxies have been applied to the carbonate phases to fingerprint the brine presence, because no pore water was sampled in these drillcores. A spectrum of diagenetic phases in the sediments has been systematically documented via petrographic examination. Carbonate cements are the most dominant, ranging from early (pre-compaction) intergranular cements to late-stage coarse fracture-fill cements, in the sedimentary records spanning from Oligocene through Pleistocene. Oxygen isotope compositions of the diagenetic carbonates in these drillcores are depleted in ^{18}O, consistent with low $\delta^{18}O$ values of the brine found in the ANDRILL SMS drillcore. Findings from the drillcores in the VLB suggest that batches of cryogenic brine had been generated in the Cenozoic, likely associated with depositional hiatuses during major Antarctic ice sheet expansions and polar climate transitions toward the Miocene and after. Emerging techniques, such as clumped isotope analysis, may provide constraints on the temperature of diagenetic fluids and the formation depth of carbonate phases to better resolve the timing of brine generation and infiltration during burial history. The presence of the brine in the VLB adds another layer to understanding basin evolution, glacial dynamics and palaeoclimatic conditions in the Cenozoic of Antarctica. This study also demonstrates potential presence of brines in the geologic record, which could have overprinted geochemical proxies used in palaeoceanographic reconstructions and geochronology. Additionally, the brines could have played an important role in the diagenetic history of sediments and hydrocarbon reservoir quality in other glaciogenic successions worldwide.

CARBON ISOTOPE ($\delta^{13}C_{CARB}$) STRATIGRAPHY OF THE EARLY–MIDDLE ORDOVICIAN (TREMADOCIAN-DARRIWILIAN) CARBONATE PLATFORM IN THE TARIM BASIN, NW CHINA: IMPLICATIONS FOR GLOBAL CORRELATIONS

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On the basis of conodont biostratigraphy and unconformities observed in the field, stable carbon isotopic analysis ($\delta^{13}C$) was performed on 210 samples from Lower–Middle Ordovician (Tremadocian to Darriwilian) carbonate mudstone, wackestone, and dolomite rocks. The samples were obtained from three profiles and several wells in the Tarim Basin, NW China. The $\delta^{13}C$ trend in the Tarim Basin profiles has four distinct characteristics: (1) a drop in $\delta^{13}C$ from -0.7‰ to -1.4‰ at the base of the Ordovician (Tremadocian), where a lithologic change occurs from large sets of dolomite (Upper Cambrian) to algal limestone and calcarenite (Lower Ordovician) and conodont Teridentus nakamural appear; (2) from the Tremadocian to the Floian, a negative shift from -1.9‰ to -3.1‰ occurred near the boundary between the Penglaiba Formation and the Yingshan Formation, where Teridentus nakamural disappear and Scolopodus tarimensis appear; (3) from the Lower Ordovician to the Middle Ordovician, a positive shift of $\delta^{13}C$ from -3‰ to -0.7‰ occurs, as the large-scale sea level rises and the sedimentary environment change from a restricted platform to an open platform, while conodont fluctuation is also observed in the Tahe region; and (4) from the Dapingian to the Darriwilian, $\delta^{13}C$ first decreases then increases, which is consistent with the rise and fall of sea level. The boundary between the Lower and Middle Ordovician is concluded to be a disconformity in the Tarim Basin based on the implication of decreasing $\delta^{13}C$ in the Floian and increasing $\delta^{13}C$ in the Dapingian. Overall, the carbon isotopes show an increase in sea level in the Middle-Lower Ordovician. In the Floian, the carbon isotopes decreased in the study area, while they first decreased and then increased in other regions.

This indicates the absence of the strata containing increasing carbon isotopes at the top of the Floian in the Tarim Basin, which may indicate a disconformity. In the Dapingian, $\delta^{13}C$ increased in the Tarim Basin and NW Russian Platform indicating a rise in the global sea level; meanwhile, $\delta^{13}C$ decreased in the Great Basin, USA and Argentine Precordillera, indicating a fall in the sea level. Relative sea level changes are known to be the main cause of changes in $\delta^{13}C$.

SEDIMENTARY CHARACTERISTICS AND MAIN CONTROLLING FACTORS OF P FORMATION IN THE NORTHERN SLOPE, BONGOR BASIN, CHAD

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Bongor basin is a passive rift basin located in the southwest of Chad, which developed in early Cretaceous affected by the central and west African rift system. This study will further characterize the sedimentary system in the study area and analyze its main controlling factors.

Base on limited cores, well logs, 3D seismic data and previous studies, P formation was divided into four 4th-order sequences: PI_Up, PI_Low, P II and P III, showing that P formation developed in the initialrift stage with alternating uplifts and depressions; According to cores observation, P formation sediments are characterized by close to the source, deepwater sediments, coarse-grained clastics and gravity flow sediments; Combined with the well logs and 3D seismic data, 3 kinds of subfacies were identified: the fan-delta front subfacies, the pro-delta subfacies, the semi-deep lake subfacies, as well as 5 micro facies: fan-delta braided channel, interdistributary bay, mouth bar, sheet sand and prodelta mud. It can be inferred that P formation mainly developed fan-delta / nearshore subaqueous fan-sublacustrine fan sedimentary system.

The seismic sections display a bidirectional onlap, and the sediments contain reductive phase of pure clay, indicating that P formation has undergone a compensated deposition with deep-water sediments. This means under setting with similar climate conditions, the tectonic subsidence rate is much higher than the sediment supply rate during the initial-rift stage. Therefore, tectonism is the key to control the sedimentary characteristics of P formation.

RELATIONSHIPS BETWEEN SEDIMENTARY CHARACTERISTICS AND MORPHOLOGICAL EVOLUTION AND PROVENANCE

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The processes and characteristics of sediments are great influenced by the paleogeomorphic and physical sources. This study utilized core, well-log, seismic data to investigate relations between sedimentary characteristics and morphological evolution and provenance in the northern slop, Bongor Basin, Chad.

According to the analysis of 3D seismic data, we learn that the diversity of slope break belt, which can be divided into single-fault slope break belt and multi-fault slope break belt, multi synthetic faults gentle-slope break belt, multi antithetic faults gentle-slope break belt, multi flexure slope break belt and sedimentary slope break belt; P formation-M formation-K formation-R formation upward provenance shows the trend of increasing transport distance and the area becoming larger. Combined with the vertical and horizontal sedimentary characteristics analysis, P formation and M formation mainly developed fan-delta / nearshore subaqueous fan-sublacustrine fan sedimentary system, K formation and R formation mainly developed braided river delta / delta sedimentary system and R formation has a larger distribution of sand bodies.

In summary, Along with the P formation fracture slope break belt evolved into R formation steep slope, slope break belt and gentle slope fold belt successively, the sedimentary facies transformed from fan delta into braided river delta / delta deposit; The provenance sedimentary features of P formation with short distance, small area gradually evolved into the K formation north gentle slope with longer distance and larger area, under its control, the fan body with small area, coarse, gravity flow characteristics evolved into the fan body with larger area, fine, traction current characteristics. It can be concluded that the morphological evolution and provenance play an important role in the sedimentary characteristics.

TECTONIC EVOLUTION AND GENETIC MECHANISM OF WAN'AN BASIN, SOUTHERN SOUTH CHINA SEA

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Based on the balanced cross-section and backstripping techniques quantitative calculation has been carried out on the tectonic subsidence and extension degree of theWan'an Basin in Western South China Sea. We reconstructed tectonic evolution history of the basin and probing into its genetic mechanism. The results indicate that tectonic subsidence curves are composed of multiple-line sections and there exist differential subsidence between middle-north and south of the basin. The basin developed two subsidence centers in Oligocene (38.6–23.3 Ma) and tectonic subsidence mainly concentrated in the middle and north, while the southern basin subsided rapidly as well in Early Miocene (23.3–16.3 Ma) and there presented three subsidence centers. Tectonic subsidence has decreased since Middle Miocene (~16.3 Ma) and the whole basin enter into post-rift thermal subsidence stage. Basin extension are closely related to the seafloor spread of South China Sea and the stretching in the middle-northern basin is ealier than the southern basin. It is inferred that alternating sinistral to dextral strike-slip motions along the Wan'an Fault Zone control on the formation and evolution of Wan'an Basin, as a result of rifting and strike-slipping. The basin tectonic evolution is divided into five stages: initial rifting, main rifting, rift-drift transition, structural inversion, and post-rift accelerated thermal subsidence.

EPHEMERAL STREAM EVOLUTION AND CONTROLLING FACTORS: A CASE STUDY OF THE MIDDLE-UPPER JURASSIC IN THE SOUTHERN JUNGGAR BASIN, NORTHWEST CHINA

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This paper presents the current body of knowledge regarding depositional evolution of ephemeral streams during the Middle–Upper Jurassic (between 166.1 and 152.1 Ma) in the southern Junggar Basin, Northwest China. The research is mainly based on analysis of satellite images, outcrop photography, lithofacies, and architectural elements of ancient and modern fluvial systems. This paper also discusses response of the ephemeral stream to tectonics, base level change, valley floor gradient, and paleoclimate.

(1) Ten types of lithofacies are summarized, including information regarding their primary sedimentary structures, characteristic lithology, and geometry. The summary of lithofacies emphasizes the dominance of structures deposited under different flow conditions.

(2) The study focused on recognizing the architectural elements within the channels (Migrating Channel-CHm, Switching Channel-CHs, Transiting Channel-CHt, and Filling Channel-CHf), the bar units (Downstream Accretion-DA, Lateral Accretion-LA, Unit Bar-UB, and Compound Bar-CB), and fine-grained clastic deposits (Floodplain Fines-FF and Overbank Fines-OF) based on the modern deposition of Junggar.

(3) Cross-sections of architectural elements were identified based on the sediment structures of the outcrops; the bounding surfaces were distinguished by the fact that they extend across the entire rock face in each outcrop.

(4) Three representative sections of outcrops were chosen in which signs of genesis and structures reflecting the evolution of a fluvial system are present.

(5) Detailed observation and analysis of the sections revealed that stream evolution during the Middle–Upper Jurassic can be divided into three stages: the braided, braided-meandering transition, and meandering stages. A sedimentary model has been created based on the reconstruction of these sedimentary characteristics.

(6) Width (W) and thickness (T) of the main sand bodies were measured in the field, and the valley floor gradients were obtained by using Google Earth. Abundant faunal and floral endemism were observed in the study area, and regional tectonics was analyzed. The base level cycle was affected by the W and T of the sand bodies.

(7) Tectonism was directly controlling the depositional system and the characteristics; Base level change had a reflection to the stream architecture. Valley floor gradient could lead to the rapid change in the scale of sandbodies, and paleoclimate had influenced evolution of sedimentation in the basin at different scales. There is an interaction between tectonics, base level change, valley floor gradients, and paleoclimate at all scales. This emphasizes the conclusion that the controlling factors cannot be ignored, even though only a component of the system is to be studied.

A NEW SCHEME FOR SEQUENCE STRATIGRAPHIC DIVISION IN DEEP-WATER GRAVITY FLOW DEPOSITIONAL SYSTEM OF MIOCENE IN LOWER CONGO BASIN, WEST AFRICA

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The classic sequence stratigraphy of Vail (1987) has the sense of milepost type in sequence stratigraphy development, although the model is mainly based on the passive continental margin as the background, but the sequence system tract division is not consistent with the West African passive continental margin basin deepwater depositional system. Because deep water deposition mainly located in the lowstand system tract, the gravity flow collapse is the main source. The lowstand, transgressive and highstand systems formed by relative sea-level change are difficult to be divided into third-order sequences in deep water gravity flow deposits. Therefore, a new division scheme should be adopted to classify the system tracts within the sequence. According to the erosion, unconformity, seismic facies change and logging response difference formed by gravity flow channel and clear two dimensional structural features of deep-water deposits and the third-order sequences are divided into allopatric depositional system tract and autochthonous deposit sedimentary system tract. The allochthonous depositional system tract is a set of deep-water gravity current deposits developed during the low sea level, autochthonous deposit system tract is a set of deep and semi marine mud deposits developed during the high sea level. Therefore, the development of the allopatric depositional system domain and the autochthonous deposit system tract is also under the control of sea-level change, but compared with the system domain of the classical sequence stratigraphy, the former can be well recognized and divided in the seismic profile. According to the definition of sequence division, a system tract is composed of multiple fourthorder sequences, and the fourth-order sequence is composed of a series of genetic related and fifth-order sequences with particular superposition. The allochtonous deposit system tracts of deep-water deposits in the Congo basin can often be interpreted as a composite channel, and the composite channel is composed of a plurality of single waterways. Therefore, a single channel can be defined as a fifth-order sequence, and a composite channel is a fourth-order sequence. That is to say, in the new deepwater sequence division scheme, the fourth-order sequence boundary is often coincident with the boundary of the system domain. According to the vertical filling model of deepwater channel, the single channel is divided into five sedimentary sections from bottom to top, and the sedimentary units within each single channel can be defined as the six stage sequence.

TIDAL VS FLUVIAL POINT BARS: KEY FEATURES WHICH DIFFERENTIATE THEM IN OUTCROPS, CORE AND WIRELINE LOGS

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The Triassic red beds of the Tabular Cover of the Iberian Meseta (TIBEM) show exceptional characteristics as a reservoir outcrop analogue, because of high quality exposure, three-dimensionality, as well as a wide variability of depositional environments. Both fluvial and transitional (tide and wave-influenced) environments are recognized. Two geobodies of similar scales (hundreds of metres in width and metre-scale thickness) but dominated by different processes have been selected in this Triassic succession. Geobody 1 is influenced by purely fluvial processes whereas geobody 2 is mostly tidally-influenced. Nevertheless, both geobodies correspond to high sinuosity channels with associated development of point bars.

In order to compare these two geobodies we have developed a workflow for data acquisition from outcrop, core and borehole (Gamma Ray and Image log) obtained from wells drilled behind the outcrop (OBO Characterization). For a better control of geobody architecture, Digital Outcrop Modelling (DOM) has been carried out using UAV (Unmanned Aerial Vehicle) photogrammetry. The aim of the study is to provide a set of key features from both outcrop and subsurface data that allows us to differentiate between tidal and fluvial point bars. As a result, a number of characteristics comprising facies associations, Gamma Ray patterns and tadpole trends are provided for each one of the environments. Digital Outcrop Modelling is used to accurately determine the shape and size of the geobodies. In this way we contribute to reducing uncertainty in the characterization of this type of reservoir and help in establishing the optimal parameters for their numerical modelling.

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CHARACTERISTICS AND ITS ENVIRONMENTAL SIGNIFICANCE OF ONCOLITES OF EOCENE GUANZHUANG FORMATION, PINGYI BASIN, EAST OF CHINA

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Oncolite usually refers to larger than 2 mm in diameter, by secreting mucus algae or microbes capture and cohere detrital material and calcium carbonate particles in the process of growth, forming the lamellar accumulations arrounding the core and non-fixed. An analysis of the development situation and causes of oncolite can instruct the sedimentary environment of the rock, and is of great significance to the lake basin evolution. Pingyi Basin in Shandong Province is a rift subsidence basin, which controlled by Mengshan fracture in Cenozoic, and there are outcrops of the oncolite exposed in Guanzhuang Formation. In this paper, microscopic characteristics, associated organisms, sedimentary structures and geochemical characteristics of oncolites were studied by field observation, microscopic identification and the geochemical test, using both macro and micro perspectives. Under the two basic units of core and layers, we analyzed the factors affecting the formation of the deposits by type. Because the core of material composition has little effect on the layers, we will focus on two different laminae, which are intertwined and superposition of shades. The changes in the color of the laminae are formed by the density and regular pattern of the algae-poor units (light laminae) and algae-rich units (dark laminae). The oncolites of the study area are divided into four categories: a) regular laminated oncolite: with large particles, multi-layer laminated, the characteristics of the composite core, indicating the environment of shallow water, medium energy and low terrigenous material injection; b) regular microsparry concentric laminated oncolite: with light color, small particle size, good separation, microsparry laminae, indicating the environment of shallow water and high energy; c) irregular micritic laminated oncolite: with characteristics of dark color, irregular shape and clotted laminae, indicating relatively deep water and low-energy environment; d) clotted oncolite: there is no discernible core, and there is no obvious lamellar structure. Oncolite is the product of intertidal zone and supratidal zone, with fully agitate in lakeshore shallow water environment. Studies have shown that shape and size of oncolite is related to the specific flow rates and turbulence and intermittent of water. Less terrigenous supply, suitable water depth and fluctuating water environment provide excellent conditions for the precipitation and rolling growth of oncolite. The oncolite of regular shape, suborbicular and concentric laminated intensive formed in a highenergy environment; the oncolite of irregular shape, small number and strongly elongated shape formed in low-energy environment. Eocene oncolite-bearing strata in this area are mainly formed in the shallow lakes of restricted lake, which are comparable to that of intertidal zone.

CHARACTERIZATION AND DISTRIBUTION OF EFFECTIVE SANDSTONE BODY OF FLUVIAL TIGHT GAS RESERVOIR, MEMBER 8 OF SHIHEZI FORMATION, SU 6 BLOCK, ORDOS BASIN, CENTRAL CHINA

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Attracted much attention in the petroleum filed during the last decade, tight sandstone gas has presently been the focus of unconventional resource development in the global natural gas exploration of China. Until 2016, the tight sandstone gas reserves account for more than one third of natural gas reserves in the whole nation, and its annual production account for 1/4 of the total, and thus, tight gas reservoir becomes the hotspot of oil and gas exploration and development in recent 20 years. As representative of tight sand gas reservoir in China, the Sulige Gas Field in the Ordos Basin has been developed and achieved rapid progresses in recent years. Su6 block, one of the key blocks in the Sulige Gas Field develops a typical tight sandstone gas reservoir with "strong heterogeneity low porosity, low permeability ", so it is a challenge to characterize and predict the effective reservoir of the main hydrocarbon zone, He8 member. The main objective of this paper is to establish a set of suitable ideas and techniques to characterize the effective sandstone body and predict its distribution with core, well log, producing data, so as to improve oil recovery and stable potential. Firstly, lithofacies classification, sedimentary microfacies and physical property of the reservoir were deeply studied with core measurement and log interpretation, and subsequently a set of quantitative recognition criteria of tight gas reservoir in member 8, su6 block was established. Secondly, the effective reservoir architecture, like vertical stack, lateral cutting and horizontal distribution within the high resolution sequence stratigraphy framework and the fluvial facies deposit pattern, was systematically anatomized. Finally, spatial distribution disciplinarian and quantitative characteristics of reservoir were predicted according to lithofacies, microfacies and petrophysical properties, meanwhile, the main geological controlling factor of sweet spots favorable distribution in He8 gas reservoir, Su6 block was revealed. The result showed that although sandstone were stacked in large area indeed, the continuity and connectivity of effective sand bodies in the study area were proved to be poor, mainly distributing in point bars and channel bars. The results of this paper provided geological basis for estimating the original volume of hydrocarbon in the reservoir, making production strategy and improving development effective of the fluvial tight gas reservoir.

KEY FACTORS OF OIL-GAS RESERVOIR-FORMING IN ORDOVICIAN CARBONATE RESERVOIRS IN GUCHENG UPLIFT, TARIM BASIN, NORTHWEST CHINA

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The Ordovician carbonate reservoir of Gucheng uplift, which is one of the most important and complex fault-controlled marine carbonate reservoirs in China, is located in the east of Tarim Basin, Northwest China. The understanding for reef flat reservoir and dolomitization reservoir once sustained hydrocarbon exploration of the Lower Paleozoic platform carbonate in the Tarim Basin. However, the ancient carbonate reservoir in Gucheng uplift has experienced significant tectonic and diagenesis throughout its long geological history. These processes have greatly complicated the reservoir properties. Especially the strong heterogeneous characteristics of the carbonate reservoir and destruction of oil-gas reservoirs increase the exploration risk in the study area. Synthetically analyzing on drilling core, thin section, fluid inclusion analysis, bitumen reflectance, and seismic interpretation, the key factors to form Ordovician oil-gas reservoirs of Gucheng area are studied as below. First, two sets of source rocks, Xidashan Formation of lower Cambrian and Heituwa Formation of Middle Ordovician, controlled the distribution of oil and gas in Gucheng uplift. Secondly, Caledonian paleostructure together with faults and unconformities provided pathways for hydrocarbon migration and accumulation. Thirdly, origin and distribution of solid bitumen, homogenization temperature of fluid inclusions, and burial-thermal evolution revealed that Permian Tectonic Heat Event was critical to the accumulation and adjustment of oil-gas reservoirs. Permian Tectonic Heat Event refer to the thermal effect of igneous rock on oil-gas reservoirs. And natural gas evolved from oil cracking at high temperature. Fourthly, two sets of important carbonate reservoirs, including the karst dolomitization reservoir of lower Ordovician and the reef flat karst reservoir of Middle Ordovician, were controlled by paleostructural geofluid processes, which was essential to reservoir accumulation. The formation and evolution of oil-gas reservoir-forming in Gucheng area withstood three stages, including the primary oil-gas pools, the destruction of paleo-oil reservoir into cracking gas, and the reformation of oil-gas reservoir. Therefore, the western area of Gucheng with good source-reservoir-cap, fairly poor faults and little magma activities are the favorable plays for hydrocarbon exploration. Our method may be useful in characterizing similar ancient marine carbonate reservoirs in other areas.

THE RESPONSE OF DELTAIC SYSTEMS TO CLIMATIC AND HYDROLOGICAL CHANGES IN DAIHAI LAKE RIFT BASIN, INNER MONGOLIA, NORTHERN CHINA

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Delta systems are ubiquitous around lacustrine rift basins, whose external geometry, progradation structure and sedimentary successions are controlled by tectonic settings and climatic changes. External geometry of deltas was strongly influenced by the depositional gradients, forming fan-like deltas on steep slopes and lobe-like deltas on gentle slopes. Due to the discharge feed rivers can change rapidly driven by climatic variations, and the nearshore area of deltas displays considerable facies variability. The rise of annual rainfall, which suggests the rivers feeding deltas were continuous, resulted in distributary mouth bars that were prevalent in the front of deltas since the down-slope flows were greater than the along-slope currents. On the contrary, the annual rainfall decreased and evaporation increased, indicating the rivers feeding deltas were ephemeral. The along-slope currents were dominant which favored the development of distal bar deposits. Progradation structure and sedimentary succession of deltas were dominated by the gradients of slopes. On the gentle depositional slopes, shingle foresets of deltas were predominated with fine sediments and small scale sedimentary structures, and vice versa.

LINKING CONTINENTAL EROSION AND MARINE MULTI-LITHOLOGY COUPLING TRANSPORT AND DEPOSITION: AN APPLICATION TO THE OGOOUÉ DELTA, GABON

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Limited attention has been given to linking continental erosion to marine transport and sedimentation in large-scale landscape evolution models. Although either of the two environments has been thoroughly investigated, the details of how erosional events are recorded in the sedimentary and stratigraphic records have not been studied in a consistent quantitative manner. Here we present results obtained from a new numerical model for marine multi-lithology (sand and silt) coupling transport and deposition that is directly coupled to FastScape, a landscape evolution model that solves the continental stream power law and hillslope diffusion equation using fully implicit and O(n) algorithms. The model of marine multi-lithology coupling transport and deposition is simulated by a nonlinear 2D diffusion model where a source term represents mass flux arising from continental river erosion. We are trying to develop a Bayesian inversion and optimisation scheme with synthetic data to validate the model. The efficient model will then be used to undertake an inversion of stratigraphic data on a natural example, Ogooué Delta, Gabon, by performing a large number of simulations. By comparing cross-section of that delta and sand and silt fraction through depth, the transport coefficients of sand and silt in the ocean environment and variations in sea level are hopefully obtained. Using our model, we will not only show the manner in which the stratigraphic record of the Ogooué Delta responds to tectonic and climate events on adjacent continents but also shows how it is controlled by the coefficients for continental river erosion, and better constrains the nature and timing of erosional events

THE CHARACTERIZATION METHODS OF MEANDERING RIVER POINT-BAR BASED ON FREQUENCY-DIVIDED SEISMIC ATTRIBUTES AND FREQUENCY-DIVIDED INVERSION

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The sedimentary environment of the upper member of Guantao Formation in Chengdao oil field, Jiyang dipression, Bohai Bay basin, is meandering river. With the guidance of meandering river quantitative architecture model, the reservoir architecture is characterized finely by the method of combining frequencydivided seismic attributes and frequency-divided inversion under conditions of large well spacing. Firstly, this paper proposed an effective method of seismic attributes optimization that performing spectrum decomposition to the seismic data and making the spectrum optimization before seismic attributes optimization. And the distribution of channel belt was depicted accurately with the optimized seismic attributes. Secondly, the point-bar recognition mark of logging, seismic attributes and frequency-divided inversion were determined. Lastly, based on the point-bar recognition mark, most point-bars were recognized finely in meander belt with the guidance of point-bar quantitative architecture model. At the same time, using the production data to verify the point-bars which were recognized. The result shows: (1) the correlation between seismic attributes and sand body thickness is improved significantly by this method. In other words, the predication of channel belt is more accuracy. (2) Channel belt and point-bar can be described accurately by the method ofcombining frequency-divided seismic attributes and frequency-divided inversion with dominant frequency of 38Hz. This method which is proposed in this paper not only can anatomize complex architecture of fluvial reservoirs effectively, but also has reference meaning to the oil field with similar sedimentary characteristics and data condition.

SEDIMENTARY CHARACTERISTICS OF OIL SHALES OF THE FAULT-DEPRESSION LAKE BASIN: A CASE STUDY ON JIANCHANG BASIN IN CHINA

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Jianchang basin located in western Liaoning Province in northeastern China, is a fault-depression lake basin of Early Cretaceous rich in oil shale. In Jiufotang formation of Early Cretaceous, oil shales developed as a set of lacustrine clastic rock deposits. The oil shale is mostly shale or mudstone. Organic geochemistry analysis shows that oil shales here are source rocks of high quality with the average TOC 1.57% and organic matter of type II or type III indicated by the relative content of C27-C29 sterane and other paramaters. The source of organic matter parent material may be mixed source input. Organic matter is immature or low mature stage with RO, CPI, and C3122S/(22S+22R) ranging from 0.41% to 0.79%, 1.1 to 3.15, 0.1 to 0.4 respectively. Besides, Tmax is below 433°C and Ts/Tm is lower than 0.1. The key parameters for the oil shale quality assessment include oil yield, desiccation-based ash productivity, thermal value and total sulphur content. The average oil yield is 5.15%, and the ash productivity ranges from 67.8% to 91.78%, the main component of which is siliceous ash. The thermal value is 4.85 kJ/g in average. In addition, total sulphur content is less than 1%, as a result of which there will be less environmental pollution in development. There is good correlation among oil yield, ash productivity, and thermal value. The higher the oil yield is, the higher the thermal value becomes, while the lower the ash productivity is. The correlation between oil yield and thermal value in Jianchang basin is obviously stronger than that between oil yield and ash productivity, and that between ash productivity and thermal value, which is different from other basins in China. According to comprehensive analysis, palaeoclimate, palaeosedimentary environment and palaeotectonics are main factors controlling the formation of oil shales. Trace elements, fossils, and biomarkers all reflect the warm and humid climate when oil shales deposited. The basin-controlling growth faults can control the accommodation space, and further influence the sedimentary thickness and quality of oil shales. From gentle slope to steep slope, the thickness gets larger and quality becomes better gradually. Geochemical index indicates the fresh-brackish reducing lacustrine environment in the sedimentary period of oil shales in Jiufotang formation of early Cretaceous in Jianchang Basin. According to research on continental sequence stratigraphy, oil shales are rich in TST when a large scale of transgression occurs and richer in HST with large sedimentary thickness and stable distribution.

EFFECT OF OROGRAPHIC PRECIPITATION ON THE GROWTH OF MOUNTAIN RANGE-FORELAND BASIN SYSTEM

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In a mountain-basin system the response of a climatic or tectonic change in terms of erosion and sediment output depends on the couplings between the mountain range and its foreland basin. Experimental and numerical models have recently brought to the fore these interactions. Classically, the modelling studies of mountain-basin evolution have considered that the rainfall it is uniform. Nevertheless, climatological studies show that the mountain ranges may have different spatial distribution of precipitation. This is the case in the Central Andes and the Himalaya and in many other ranges, where it is possible to distinguish rainfall peaks or orographic precipitation. Prior studies have suggested that rainfall distribution influences the mountain relief in a steady state. Thus, by considering homogeneous precipitation in models we probably miss a fundamental link between the mountainbasin development, the uplift and climate. How does the mountainbasin reacts when orographic precipitations strengthen during the surface uplift remains an open question to be investigated. In particular, we speculate that the development of precipitation peaks may lead to sediment output variations. We present the results obtained using a landscape evolution model, CIDRE, which allows to explore the response of a mountain-piedmont system while it is growing. In this system, the mountain is continuously uplifted but the precipitation rates depend on the elevation mountain. The elevationprecipitation relationship takes the form of Gaussian curves simulating a broad range of monsoon precipitations of different magnitudes and at different elevations. The results of the modeling suggest that the evolution of denudation rate of mountain is completely controlled by the distribution of orographic precipitation. This means that, when the maximum mountain elevation reaches the altitude of orographic precipitation, the denudation rate is strongly accelerated or even peaks. This mountain denudation acceleration can be reflected within the piedmont by an increased sediment deposition. On the other hand, if the maximum mountain elevation exceeds the altitude where the orographic precipitation occurs, the denudation rates tend to stabilized and increases very slowly. The system is then close to a state of dynamic equilibrium but with de denudation rate far smaller than the rock uplift rate. Considering this, the sediment flux produced by the change in the evolution of the denudation rate could be characteristic in the evolution of a mountain range and may explain sediment some deposition pulses in natural basins. This results highlight the importance of considering the rainfall distribution on the evolution of a mountain-piedmont system in order to infer a mountain behavior from changes in the sedimentation rates in the piedmont.

AN OVERVIEW OF THE PETROLEUM SYSTEMS IN GREECE: FROM OFFSHORE APULIAN PLATFORM MEDITERRANEAN RIDGE NW AEGEAN SEA, TO ONSHORE IONIAN AND MESOHELLENIC BASINS. STRATEGIC PLANNING OF THE INDUSTRY'S DEVELOPMENT IN GREECE

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The Hellenic part of the Fold and Thrust Belt (FTB) in the Balkan Peninsula has been explored regarding its hydrocarbon potential since it exhibits, in broad terms, similar geological history to the prolific oil and gas provinces in Albania and Italy. Regional analysis indicates a MidMesozoic and a Tertiary hydrocarbon system. Exploration opportunities include: 1) the onshore Mesohellenic basin and the Pindos thrusts' foreland basin, 2) the offshore Ionian thrusts' foreland basin, the basin north of the Borsh-Khardhiqit strike-slip fault and Preveza basin, north of the Cephalonia transfer fault. Fundamentally, the suggested targets all have in common that they represent sedimentary (sub-) basins of substantial thicknesses which are, in one way or another, correlated with tectonic movements (the evolution of the Hellenic FTB).

The Mediterranean Ridge (M.R) is bordered on the north by deep and narrow trenches forming the Hellenic Trench system (H.T.S). The southern boundary of the M.R. is delineated by a chain of flat abyssal plains adjoin to the African margin. Mud volcanoes are present in the M.R. Their occurrence is broadly distributed in predominantly active margins, often situated along faults, fault-related folds, and anticline axes. These structures act as preferential pathways for deep fluids to gather and ultimately reach the surface. Exploration opportunities include: 1) Anticlines and faulted anticlines in the Paleozoic to Pliocene (West of Zakynthos Island), 2) Fault blocks and combined fault/stratigraphic traps in Mesozoic to Pliocene (West of Zakynthos Island and South Cretan Margin, in basins in the backstop of the H.T.S.), 3) Anticlines associated with diapiric movements (between the Pliny and Strabo Trenches, between Crete and the Cyrenaica, southwest of Peloponnesus).

The Thrace Basin (TB) occupies the north Aegean Sea and is exposed in the Hellenic, Turkish and Bulgarian territory, where economically significant reserves of gas, oil and associated condensate have been discovered. TB is the most productive gas and oil region of Turkey and hosts the only commercial oil field in the Hellenic domain. Exploration opportunities include the thick forced regressive submarine fans that form the bulk of the late Eocene-early Oligocene sedimentation. Reservoir analysis data allow their consideration as both oil and gas reservoirs, sourced and sealed by all underlying and overlying facies respectively (basinfloor fan, slope facies).

THE LARGE BRAIDED RIVER DELTAIC DEVELOPMENT AND STRATIGRAPHIC ARCHITECTURE IN SHALLOW LACUSTRINE – A CASE STUDY FROM BASHIJIQIKE FORMATION OF CRETACEOUS, KUQA DEPRESSION, TARIM BASIN

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Large braided river delta was developed in shallow lacustrine, which is an important oil and gas exploration field. Tectonic and sedimentary evolution in Kuqa depression of Tarim basin experienced three stages, strong structural extrusion stage between 134-126 Ma (Yageliemu Formation), stress release and rapid subsidence stage between 126-109 Ma (Shushanhe-Baxigai Fomation), slow subsidence stage and formed shallow sedimentary basin between 109-92 Ma (Bashijiqike Formation). Five large shallow braided river deltas were developed in the stage (109-92 Ma, Bashijiqike Formation) and their distribution area was about 2000 square kilometers. And trillions of cubic natural gas reserves were proved. It's thought that sand body construction and stratigraphic architecture is the key problem to oil and gas exploration and development.

By means of research of outcrop section, seismic, logging and experimental data, the characteristics of the braided river deltaic development and stratigraphic architecture were revealed that dry ancient climate period, a lot of shallow water sedimentary mark, mud crack abundant shallow water trace fossil assemblages more than the thickness of 350 meters, the lithology of fine sandstone, siltstone and small amount of mudstone, with high sandstone proportion (80%-90%). Five patterns of sand body construction in vertical were recognized and 80% was box-logging type of distributary channel sandstone. The thickness of mudstone layer was only 0.5-1 meter, with 50-100 meters extended distance.

The conclusions can be drawn that the large braided river delta was developed on the background of shallow lacustrine, with big sedimentary thickness and high proportion of sand thickness to stratigraphic thickness. The dominant sand body was the distributary channel, which accreted vertically to compound sand body, with large area distribution. The mudstone had thin thickness and short extended distance. And therefore, looking for the large anticline reservoir of distributary channel sandstone is the key factor to increase reserves and production.

EFFECTS OF TIDAL HIGH-FREQUENCY SEA-LEVEL CHANGES TO SAND RESERVOIR AND OIL ACCUMULATION — STUDYING ON THE SILURIAN IN TAZHONG AREA, TARIM BASIN, CHINA

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The “V”-type estuary and bay of Silurian in Tazhong area is a region with strong tidal hydrodynamic effect. The material carried by the river, reconstructed by tidal hydrodynamic and high-frequency sea-level change, made the complex sandbodies. So, the relationship between hydrocarbon accumulation and structure of the sandbodies (vertical stacking and lateral spreading) is the key for oil exploration and development in this area. The sandbody type and petrographic characteristics were analyzed according to core description, logging, high resolution geophysical data and field sandbody data. Then, the internal structures of the sand reservoir were analyzed based on the experimental data of cast slab, laser confocal, scanning electron microscope and CT Scanning. All the results show that four types of sandbodies, six lithofacies and two kinds of middle-high effective reservoirs are developed in the Silurian reservoir, forming two configurations of sandbodies. According to that, high-quality sandstone reservoirs were formed in channel and tidal bar during the regressive period, controlling the oil accumulation. At last, it has been proved that inclined well drilling and segmented sand fracturing operation for the better sandbodies are important measures for oil and gas exploration and development of Silurian in Tazhong area.

A MIDDLE-MIOCENE SUBMARINE-FAN SYSTEM IN THE NIGER DELTA BASIN: INSIGHTS INTO THE CONTROLS OF HIGH-FREQUENCY SEA-LEVEL CHANGE ON THE SUBMARINE-FAN ARCHITECTURE EVOLUTION

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It has been controversial concerning how the architecture evolution of submarine-fan systems is related to the sea-level change, due to the common lack of reasoning from real sea-level curves. In an effort to unravel their coupling relationships, this study correlates the architecture dissection results from a MiddleMiocene submarine-fan system in the Niger delta basin, which is based on an integration of cores, well-logs and 3-D seismic data, with the benthic-oxygen-isotope-derived high-frequency sea-level curves in West Africa. The possible controlling mechanisms are discussed as well.

This study concentrates on a 3rd-order sequence, which comprises a lowstand tract and a transgression-highstand tract. The lowstand tract develops one channel system ended by a large-scale lobe system, whereas two vertically-superimposed channel systems developed in the transgression-highstand tract. A detailed well-seismic tie within the channel systems reveals the commonly multi-periodic filling by channel complexes, which are further composed of multiple individual channels with various stacking patterns. And core-wireline calibration further yields four types of successions within an individual channel, including slumped, sand-prone, mixed sand-mud, and mud-prone successions, which evolve gradually upwards in a complete channel system. Comparatively, the lowstand lobe system evolves from bottom mass-transport complexes to sand-prone lobe complex, mixed sand-mud channel complex, and mud-filled channels.

The high-frequency sea-level curve shows the complete 3rd-order sea-level cycle consists of three 4th-order fall-rise cycles, which controls the development of the three channel systems as well as the terminal lobe system, as evidenced by their well correspondence. Besides, one 4th-order sea-level cycle comprises four or five 5th-order cycles, whose well correspondence with the multi-periodic channel/lobe complexes implies a direct control of 5th-order cycle on the development of one-periodic sedimentary complex. Integrated analysis suggests that a relatively large-amplitude sea-level fall is a prerequisite for the development of submarine-fan systems irrespective of the hierarchies. And above all, the variations in the gravity-flow clay content induced by the different-ordered sea-level change contribute significantly to the architecture evolution of submarine-fan systems. In this view, an evolution pattern linked to sea-level change is ultimately established.

BASALT LEACHING AND DEEP CIRCULATING DOLOMITIZATION: A NEW MODEL OF DOLOMITIZATION BASED ON MIDDLE PERMIAN DOLOSTONES IN YANGTZE PLATFORM

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Dolostones developed widely in Yangtze platform (China) during the Middle Permian. The crystal distribution in the dolostones is unimodal, and the crystals mainly consist of fineand medium-grained dolomites. The host rocks of the dolostones are mainly bioclastic grainstones. Fluid inclusion analysis indicates that the dolomitizing fluids were relatively hot (78° C to 185° C). Cathodoluminescence indicates that the dolostones formed in a stable reducing environment. Previously reported dolostone formation mechanisms cannot explain the distribution and geochemical characteristics of dolostones in Yangtze platform. To help predict the distribution of dolostone reservoirs and reduce exploration risk and cost, this study proposes a new model of dolomitization: basalt leaching and deep circulating dolomitization. In the new dolomitization model, the Mg^{2+} of dolomitizing fluids comes from the weathering decomposition of the ferromagnesian minerals in the basalt, and the dolomitization fluid is the atmospheric precipitation that leaches the Emei basalt. Driven by topography and geothermal gradient, the fluid circulated deeply from the southwest (the Emei basalt coverage area with high geothermal gradient) to the north (the area outside the Emei basalt coverage area with low geothermal gradient) of the Yangtze platform, resulting in large-scale dolomitization during the Middle Permian. The fluid temperature gradually decreased during this fluid migration. The dolostones are mainly distributed in the basalt coverage area and the adjacent coverage area with the barrier conditions [Longtan Formation (shale) coverage area]. The depositional setting of the dolostones was shoal facies. This model not only explains the characteristics and distribution of dolostones in the study area but can also be used to predict the distributions of dolostones in other areas associated with basalt or magnesium-rich rocks.

DEPOSITIONAL EVOLUTION OF THE EARLY CARBONIFEROUS CARBONATE PLATFORM AND DEVELOPMENT OF FAVORABLE RESERVOIRS IN THE CHU-SARYSU BASIN, KAZAKHSTAN

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The Early Carboniferous carbonate section is the most potential petroleum bearing interval in the Chu-Sarysu Basin. The reservoirs in the carbonate deposits are variable and constrained by many factors including facies architecture and diagenesis and evolution of the carbonate platform. Based on integral analysis of cores, thin sections, loggings and seismic profiles, the sequence architecture, depositional evolution of the carbonate platform and favorable reservoir types are investigated in the paper. The Lower Carboniferous carbonate system in the basin is recognized as one composite sequence defined by major unconformities, and can be further divided into four sequences (Sq1-4) and a number of four-order sequences based on local transgressive and regressive interfaces. Each sequence consists generally of a local depositional cycle from a transgressive systems tract (TST) to a highstand systems tract (HST). There are four major microfacies associations identified based on examination of more than 400 slices and loggings profiles, which represent different depositional environments of the carbonate platforms: (1) ring or patch reef deposits of platform margin, comprising mainly of framestone and bioclastic grainstone; (2) high to middle energy platform margin shoal deposits, consisting mainly of bioclastic, intraclast or oolitic grainstone; (3) low energy dolomitic tidal flat deposits, including predominately dolomitic biocalstic wackestone and biocalstic packstone; (4) low energy interband sea or lagoon deposits, composed mostly of biocalstic wackestone, cryptite and dolomite. The carbonate platform was built up during the Visean Stage and five facies zones are recognized from southwest to northeast: peritidal area, restricted platform, open platform, platform margin and slope. The largest transgression occurred during Sq3, and low energy interbank sea environments dominate. During Sq4, widespread reef and shoal environments developed. Three major types of favorable reservoirs found in the carbonate section are cavernous reservoir, reef-shoal reservoir and dolomitic reservoir. Reef-shoal reservoirs were mainly formed in highstand systems tracts of Sq4 along high energy platform margins; cavernous reservoirs in the Sq3-4 related to epigenic karstification; and dolomitic reservoirs consist mostly of relict texture dolomite which may be related to penecontemporaneous dolomitization.

DID THE PALAEO-YARLUNG RIVER FLOW INTO THE IRRAWADDY DRAINAGE IN THE PALEOGENE?

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Southeast of the eastern Himalayan syntaxis, northeastward subduction of the Bengal oceanic crust beneath the Sunda plate created the forearc-backarc couplet of the Central Myanmar Basin (CMB) along which the modern Irrawaddy River flows south into the Andaman Sea. The CMB is dominated by an almost continuous succession of Late Cretaceous-Cenozoic sedimentary rocks and thus provides a relatively complete stratigraphic record of the evolution of the palaeodrainage of the basin.

Previous work on the Paleogene CMB sediments, centred around the fact that detrital zircons of Mesozoic-Paleogene age and positive εHf signature are similar in age and εHf signature to zircons of the Trans-Himalaya in the Yarlung Tsangpo drainage, and unlike the signature of grains from the intra-Burman arc granitoids, which have negative εHf signatures. From this it was inferred that the palaeo-Yarlung Tsangpo, which drains east along the India-Asia suture zone in its upper reaches, used to then drain into the Irrawaddy CMB downstream in the Paleogene, before river capture by the Brahmaputra diverted the river's downstream reaches to the Bengal Basin in the Neogene. However, Wang et al. (2014) proposed that Mesozoic-Paleogene aged detrital zircons with positive εHf signatures found in the CMB could have been derived from the local Western Myanmar Arc (WMA; also called Wuntho Arc), despite the fact that these authors had no associated bedrock data to support their proposal.

We analyzed igneous and sedimentary subsurface samples from wells that penetrated to theWestern Myanmar Arc igneous bedrock beneath the basin sediments, using U-Pb and Hf isotopes of zircon, U-Pb dating of rutile, and Sr-Nd bulk analytical techniques. We show that:

(1) Bedrock zircons from igneous rocks of the WMA have Mesozoic-Paleogene ages and positive εHf signatures similar to Trans-Himalayan zircons. The WMA thus provides a suitable source for detrital zircons of the Paleogene CMB which also have Mesozoic-Paleogene ages and positive εHf values; long distance provenance from the Yarlung Tsangpo drainage is thus not required to explain the detrital data.

(2) Rutile U-Pb ages from our WMA igneous bedrock samples give predominantly Mesozoic and Lower Paleozoic to Late Precambrian ages. Our detrital rutile data from the CMB show a change between Eocene times, when rutile grains are arc-derived, and Oligocene times, when Cenozoic grains are recorded.

We interpret the Cenozoic grains as derived from the Mogok Metamorphic Belt (MMB) and the provenance change recorded in the CMB as due to evolution of the palaeo-Irrawaddy drainage basin to encompass regions as far north as the MMB at this time. Integration of our interpretations with both our new and published bulk-rock Sr-Nd isotopic data and zircon U-Pb dating with Hf analyses will be discussed.

MICROSCOPIC PORE TYPE AND CLASSIFICATION CRITERION OF SHALE RESERVOIR-A CASE FROM THE SHAHEJIE FORMATION IN ZHANHUA SAG, BOHAI BAY BASIN

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Compared with the conventional reservoir, the shale reservoir space is mainly composed of micronsize and nano-size pores. The type, geometric shape, distribution and origin of the shale reservoir space are more complicated than those in the conventional reservoir. Moreover, the current classification and naming system of shale reservoir space are multiple and need to be unified. In this study, mass of experiments and tests such as thin section, SEM, X-ray diffraction, Nano-CT, high pressure mercury injection and gas (including nitrogen and carbon dioxide) adsorption from samples of shale reservoir of the Shahejie Formation of Paleogene in Zhanhua Sag, Bohai Bay Basin, were conducted so as to define the pore type, morphological characteristics, the classification criteria and naming schemes of microscopic shale reservoir space.

Considering the factors such as occurrence, location, origin, pore size and so on, a comprehensive classification scheme of microscopic pore of shale following scientific, systematic, simple and practical rules was proposed. First, according to the occurrence, the shale reservoir space was divided into “pore” vs. “crack” two classes. Then, on the basis of the location, the pore was subdivided into “matrix pore” and “organic matter pore” categories. The matrix pore was further divided into intergranular pore, intragranular pore and grain edge pore. Organic matter pore includeed inner pore and edge pore. All types of these pores were further divided into primary and secondary pore. According to the occurrence, crack was divided into matrix crack and organic matrix crack. The former is further divided into interlaminar, structural and diagenetic cracks based on the occurrence and the origin. The later was further divided into inner and grain boundary organic matter crack according to the position.

The criterion for evaluating the pore was determined according to the size of pore diameter, namely pico-size pore (< 1nm), nano-size pore (1 nm to 1 μm), micron-size pore (1 μm to 1mm) and macroscopic pore (> 1mm). Meanwhile, pores were divided into micro-pore (< 2 nm), meso-pore (2 nm to 50 nm) and macro-pore (> 50 mm) after IUPAC criterion. Cracks according to the width of crack were divided into nano-size crack (< 1μm), micron-size crack (1 μm to 1mm) and macroscopic crack (> 1mm). Different pore types correspond with different pore sizes. The matrix pores are mainly nano-size, only a small amount of micron-size pores; while the organic matter pores are dominated by nano-size pores, and there are almost no micron-size pores. Structural cracks are mainly macroscopic millimeter-size cracks. Diagenetic cracks are mainly micron-size cracks. While the organic matter cracks mainly nanosize cracks. These research achievements will provide a scientific foundation for the development of microscopic shale reservoir evaluation, exploration and development program.

PALEOSALINITY AND WATER BODY TYPE OF EOCENE PINGU FORMATION, XIHU DEPRESSION, EAST CHINA SEA BASIN

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Xihu Depression is a relatively new petroleum exploration area in East China Sea Basin. Pinghu Formation is one of the most important oil-bearing formations in the depression. Due to the low exploration level of the depression, paleosalinity and deposition environment of the depression in Pinghu stage is not clear. Element geochemical analysis of samples from different structural units is used to study ancient water salinity and reveal the depositional environment. B/Ga ratio, which is sensitive to paleosalinity in study area, is 0.9~4.0 and indicates characteristics of mixed water of fresh and salt water. There is a threshold for Sr/Ba in water salinity study in the study area. When Sr/Ba ratio is lower than 0.15, it cannot be used as an indicator for salinity and ancient water body type. Equivalent boron content calculated by Walker's method is lower than 150 ppm. Paleosalinity from boron content calculated by Couch's method is 2.97‰~ 9.6‰ and the average is 4.8‰. Based on the above mentioned results, ancient water body of Xihu Depression in Pinghu stage has typical characteristics of brackish water and it belongs to oligohaline and mesohaline water. Combining paleogeomorphology and sedimentary facies distribution in the study area, paleowater body in Xihu Depression during Pinghu stage is transitional mixed water influenced by terrigenous diluted water. Paleosalinity contour lines extend on plane from north to the south and are parallel to paleo-coastline. Paleosalinity increases from the west to the east. Influenced by freshwater of deltas at western part of the depression, high abnormal salinity values occur around the wells M1 and L1 where salinity contour lines curve westward.

SEISMIC SEDIMENTOLOGIC INTERPRETATION OF FLUVIAL RESERVOIR ARCHITECTURE IN MATURING OILFIELDS

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Reservoir architecture was generally characterized with outcrops and wells. But in petroleum reservoir study, it is found that interwell reservoir architecture is not clear even in mature oilfields with dense well net. In this study, a seismic sedimentology method is developed to characterize reservoir architecture of point bar complex. There are 3 challenges: 1) thin bed VS seismic resolution limit; 2) mismatch of different data including seismic data, well logs and dynamic oil production data; 3) geological meaning of seismic reflection in thin bed.

In this case study, 3D seismic data, drilling cores, well logs and production data of 200 wells (include 5 drilling core wells) are used. This work is focused on three levels of reservoir architectures: sedimentary microfacies (point bar complex), single point bar and lateral accretion sand body. In study of the first and second levels, seismic interpretation technologies, such as seismic facies analysis, strata slice and multi-seismic attributes analysis, are used. For lateral accretion body characterization, seismic technologies (including frequency decomposition and reconstruction, seismic attributes and slice interpretation), sedimentology analyzes methods, quantitative knowledge base and dynamic production data (including water and tracers injection data) are integrated. Main lateral accretion boundaries are recognized in this result.

In this study, the area, which was thought to be a single point bar deposition, is proved to be formed by a point bar complex. It has three single point bars which were formed in different periods. Point bar #1 was formed in the first period, and then point bar #2 eroded it. Point bar #3 was formed in the last deposition period. They formed very complex and heterogeneous reservoir. Such a deposition process can also be observed in modern depositions. This seismic interpretation result has been verified by well logs of new wells and production data. This result is very important in both the reconstruction of paleodeposition and the recognition of the deposition processing. The result can also be used in prediction and development of remaining oil.

TYPES AND CHARACTERISTICS OF SAND BODY IN MULT-HYDRODYNAMIC ACTION DEPOSITIONAL SYSTEM, A CASE STUDY FROM SILURIAN OF TAZHONG UPLIFT IN TARIM BASIN, NW CHINA

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Tazhong Uplift is located in the center of Taklimakan Desert in Tarim basin, northwest in China. There is a large oilfield in Silurian belonging to Tarim Oilfield Company. Resulted from the special sedimentary background with three-uplifts, the action of deposition is controlled by several kinds of hydrodynamic force (wave, tide and river) corporately but in different extent, and results to various types of sand body with complicated structure in Silurian. Therefore, identification of sand body types, and the rule of their horizontal and vertical distribution and superimposition is the key question in the hydrocarbon exploration and development in Silurian in Tazhong oilfield. By studying and analyzing the combination of drilling core, logging curve, high-resolution geophysical data in Silurian, 6 types of sand body are identified. TZ I Tectonic Zone is influenced mainly by wave and primarily develops sand bar in shoreface. TZ 10 Tectonic Zone is mainly impacted by tidal and develops sand flat, tidal channel, tidal sand bar. TZ High Area is affected by fluviation mainly and tidal in some extent, consequently develops underwater distributary channel, sheet sand in tidal delta front. Taking advantage of a variety of experimental means, e.g. casting thin sections, laser confocal scanning microscope, scanning electron microscopy, rate-controlled mercury penetration, industrial CT and so on, the petrolgic characteristics, type and content of interstitial material, size and structure of the pore and throat is characterized qualitatively and quantitatively in the reservoir of these 6 sand body types. the experimental results show that tidal channel is the optimal reservoir, which is characterized by higher content of the rigid particle with lower content of interstitial material, larger pore and throat, better reservoir property than these of the other 5 sand body types. Its average content of quartz is 70%; interstitial material is mainly dominated by illite and kaolinite, whose average content is 7%; pore type is dominated by intergranular dissolved pore and primary pore. Throats are schistic and curved lamellar. Pore radius is 20-200 μm. Throat radius is 10^{-35} μm; the average porosity is 14.5%. the average permeability is 61×10^{-3} μm^2. It indicates that it is medium-high-commercial reservoir. Besides, this kind of high-quality reservoir is also the best sand.

COUPLING RELATIONSHIP BETWEEN GRAIN BEACH DOLOMITE RESERVOIR AND SEA-LEVEL FLUCTUATION, A CASE STUDY FROM ORDOVICIAN RESERVOIRS OF GUCHENG UPLIFT IN TARIM BASIN, NW CHINA

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The Ordovician reservoir of Gucheng uplift, which is one of the most important and complex faultcontrolled carbonate reservoirs in China, is located in the east of Tarim Basin. During the period of Ordovician, the study area was shallow-water carbonate platform facies deposition. And the ancient marine carbonate reservoir has become one of the most important hydrocarbon exploration targets in China due to thick layer and relative good porosity. However, the ancient carbonate reservoir in Gucheng uplift has experienced significant tectonic and diagenesis throughout its long geological history. These processes have greatly complicated the reservoir properties. It's thought that strong reservoir heterogeneity and difficult prediction of high quality reservoir are the key constraints. Global sea-level fluctuation could be characterized by stable carbon isotope values (abbreviated as $\delta^{13}C$). We describe carbonate sedimentology and sequence stratigraphy integrating core carbon isotope, well log and seismic data, to reveal coupling relationship between grain beach dolomite and sea-level fluctuation. The Ordovician sequence stratigraphy of Gucheng uplift can be divided into three sea-level ascending and descending sequence cycles. The bottom of Sequence 1 has $\delta^{13}C$ values ranging from -1.7 to -1.14‰ VPDB, $\delta^{13}C$ values transition to ranging from +0.35 to +0.74‰VPDB, with the top of the sequence 1 $\delta^{13}C$ values ranging from -1.23 to -0.66‰ VPDB, which reflects a complete sequence cycle of sea-level rise and fall. Similarly with Sequence 2. $\delta^{13}C$ values of the bottom of Sequence 3 are from -2.4 to -0.3‰ VPDB, with the top ranging from +0.2 to +1.4‰ VPDB. It has negative-positive cycle feature, which reflects a half sequence cycle of sea-level rise. Development and distribution of grain beach dolomite reservoir is controlled by sea level rise and fall. During the sea level falling period, highenergy grain beach deposited in palaeogeomorphology highland, and suffered from meteoric water leaching during penecontemporaneous period. And then was modified by hydrothermal dissolution transported along fracture. And therefore, the grain beach dolomite reservoir is widely distributed during the sea level fall period. On the contrary, the grain beach dolomite reservoir is limited distributed during the sea level rise period. Our method may be useful in characterizing similar shallow-water carbonate platform grain beach dolomite reservoir in other areas.

CHANGES OF SEDIMENTARY AND TECTONIC FEATURES OF PALEOGENE IN LENGHU AREA, QAIDAM BASIN: RESPONSE TO THE TIBETAN PLATEAU UPLIFTING

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Lenghu structural belt is located in the northern margin of Qaidam Basin, which formed as a consequence of the Tibetan plateau formation during the Cenozoic Indo-Asian collision, and it kept a sedimentary record of the geological events occurred in surrounding Altyn Tagh and Qilian Mountains. Several phenomena indicate the sinistral movement of the Altyn Tagh Fault (abbr. ATF), one is that the direction of paleocurrent inferred from dip logging and seismic reflection, and provenance analyzed by heavy mineral assemblages during the Paleogene has both experienced a slight clockwise deflection in the Oligocene, changed into westward from southwestward in Eocene. Another is that the complex fault system in the area show a steadily thrust formation in the whole Cenozoic influenced by the Tibetan Plateau uplifting, it is noticeable that the fault activity enhanced synchronously in the Oligocene, especially thrust faults along northeast-southwest direction. This coincides with the analysis of sand content, which indicates that there is an abruptly strengthening of sediment supply in Oligocene during the Paleogene, compared to the continually weakened from the beginning to the end of Eocene.

This study aim to decipher the uplifting process of Tibetan Plateau during the Paleogene period, and describe the role it played in the sedimentary and tectonic evolution along the northern margin of Qaidam Basin. A regional uplift and denudation event along the northeastern Tibetan Plateau during early Oligocene is inferred, which indicates that the Tibetan Plateau had expanded north-eastward of the study area at that time. And the sedimentary record of Oligocene indicates an evidence to the rapid uplift of Qilian Mountains and the sinistral transpression related to the motion on ATF, which in response to the intensive tectonic deformation in basin effected by the second uplift of Tibetan Plateau as a result of the complete collision of India and Asian plates.

THE SEDIMENTARY STUDY OF MESOZOIC STRATUM IN CHAOSHAN DEPRESSION, NORTHERN SOUTH CHINA SEA

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A suite of well-developed and thick Mesozoic strata was developed in Chaoshan Depression, northern South China Sea. As the exploration level in Chaoshan Depression is extremely low, this study discusses the architecture of Mesozoic strata, sedimentary system and evolution process in Chaoshan Depression by the existing two-dimensional seismic data. The principal results are as follows: (1) By analyzing the features of seismic reflection termination relationship, the Mesozoic strata framework in Chaoshan Depression is established. And six tectonic interfaces (Tj0, Tj2, Tj1, Tk0, Tk1 and Tg) are identified in study area. (2) The seismic facies in Jurassic consist of subparallel-wavelike and parallel reflection configuration. The study shows that fluvial plain, delta, coastal plain, offshore and bathyal developed from the northwest to the southeast in Chaoshan Depression. Unlike Jurassic, the main seismic facies of Cretaceous stratum is parallel reflection configuration. Shelf break couldn't be discerned in Chaoshan Depression in Cretaceous. And fluvial plain, delta, coastal plain, offshore developed during Cretaceous. (3) During the early Jurassic, a large scale of transgression occurred in Chaoshan Depression. The major sediments originated from northwest and west of the study area. Coastal plain and offshore widely developed in the area. The delta retrograded to the northwest in early Jurassic while a large scale of regression occurred in the middle Jurassic. Delta prograded toward the sea and the marine depositional area continued to decrease in middle Jurassic. During the late Jurassic, another large scale of transgression occurred in Chaoshan Depression. The bathyal region mainly extended from NNW to SSE and developed in the southeast part of the study area. Abundant slumps and slope fans developed on the steep slope zone. During the Cretaceous, transitional facies developed in Chaoshan Depression. The major sediments originated from the northwest. Fluvial plain, delta facies and turbidite channels developed from northwest to the southeast in Chaoshan Depression in Cretaceous. Chaoshan Depression is a significant area for the oil and gas explorations. And this research will form a basis for the further exploration.

PETROLOGICAL CHARACTERISTICS OF HYDROTHERMALSEDIMENTARY ROCKS IN THE LOWERCRETACEOUS FROM BAYINCHAGAN SAG, EARLIAN BASIN, CHINA

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The hydrothermal-sedimentary rocks have been identified in the deep-lacustrine mudstone of the Lower Cretaceous Tengger Formation from Baiyinchagan Sag, where is located in the western Erlian Basin of northern China. The petrological characteristics of hydrothermal-sedimentary rocks were systemically studied on basis of the data of drilling, well logging, cores and analysis of QEMScan, polarizing microscope, scanning electron microscope, electron probe and energy spectrum, whole rock X-ray diffraction, etc. The analysed results show that the hydrothermal-sedimentary rocks are mainly composed of ferroan dolomite (Fe content 0.5%-5%) and zeolite (including natrolite and analcime). Minor minerals are magnesite, pyrite, barite and sjogrenite. In addition, the rocks mixed with abundant terrigenous clastic composition including feldspars, clay minerals and minor quarts. The petrological textures of hydrothermal-sedimentary rocks divide into four types in terms of crystal size and different mineral assemblage, they are pelitic, micritic, intraclastic and crumbed. These rocks grow into complicated and various rock structures from macroscopical scale. Commonly, laminated and banded rocks are interbedded into mudstones in which synsedimentary deformation can be recognized, and abundant white intraclasts dispersedly distribute in dark mudstones. There are also brecciated structure, network-vein structure and massive structure being identified. Vertically, hydrothermal-sedimentary rocks form four obvious hydrothermal sedimentary cycles in Lower Cretaceous Tengger Formation from research area. Horizontally, hydrothermal sedimentary rocks mainly distribute along the fault, and are mainly located in the downsliping block of faults. Whereas hydrothermal-sedimentary rocks are thin and undevelop in the uplifting block or away from the faults. The petrological characteristics of rocks indicate this type of rocks falls into 'white smoke type' hydrothermal deposition affected by thermal fluids migrating though faults into lacustrine sediment in research area.

STURTIAN GLACIAL DEPOSITION IN THE YANGTZE BLOCK OF SOUTH CHINA

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The international Commission on Stratigraphy has formally approved the replacement of previous basal Cryogenian GSSA at 850 Ma with a rock-based GSSP at ~720 Ma, the new Cryogenian GSSP will be placed at a globally correlative level that lies stratigraphically beneath the first appearance of widespread glaciation. The Neoproterozoic Sturtian glacigenic succession (716-670 Ma) deposited in the Yangtze block of South China varies in thickness from less than 10 m to more than 2000 m. These dramatic thickness changes are mainly attributed to a pre-existing platformslopebasin topography across the Yangtze block. Consistent with the variation of thicknesses, only a thin unit of diamictite (Gucheng Formation) occurs in the platform facies, whereas a much complex assemblage of units including diamictite, Banded Iron Formation (BIF), and sandy turbidite occurs in deep water basinal facies (Jiangkou Formation, or Chang'an+Fulu+Tiesiao Formations), representing the most complete deposition during the Sturtian glaciation in South China. In the basinal setting, massive diamictite constitute > 90% of Chang'an Formation and have a thickness of > 1000m. The overlying Fulu Formation consist of, in ascending order, BIF (usually less than 10 m), sandy turbidite intercalated with thin pebbly sandstone (50 m), and sandstone beds with parallel bedding structure (150 m). Tiesiao Formation is dominated by glacial diamictite. The lithofacies change from the Chang'an to Tiesiao Formations in the Yangtze block probably demonstrate a much complex glacial-deglacial process during the Sturtian glaciation. Two tuffaceous siltstone samples from the uppermost Gongdong Formation yield SIMS zircon U-Pb age at ~716 Ma, which is synchronous with dates obtained from the lowermost parts of glaciogenic successions in Canada and Oman, furthering supporting a global synchroneity for the Sturtian glaciation. The newly discovered Sturtian cap carbonate in eastern Guizhou Province demonstrates a positive $\delta^{13}C$ shift, resembling that of Sturtian cap carbonate in Congo and Kalahari cratons. Field investigations in southeastern Guizhou and northern Guangxi Provinces indicate a continuous deposition from preglacial siliciclastics of Gongdong Formation to glacial diamictite of the Chang'an Formation in the basinal facies of the Yangtze block. The first appearance of dropstone in laminated siliciclastics may indicate the onset of this global glaciation and serve as a defining marker for the basal Cryogenian GSSP.

PETROLEUM SYSTEM ANALYSIS OF WZ12-2 OILFIELD IN THE POORLY DEVOLOPED WEIXI'NAN SAG IN BEIBUWAN BASIN, SOUTHERN CHINA

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Hydrocarbon exploration is at an early stage in Beibuwan Basin that locates in southern China. Weixi'nan sag that lies in the northeast part of Northern Depression of the basin has made some important hydrocarbon breakthroughs recently. WZ12-2 oilfield, located in south part of B subsag is the main oil producing area. To advance our understanding of the reservoir forming process, petroleum system of WZ12-2 oilfield of Weixi'nan sag is studied combing geochemical analysis of oil and shale samples collected from drill cuttings and,where available, cores and basin modeling work. Oil-source rock correlation resulted from biomarkers and carbon isotope suggest that oils accumulated in WZ12-2 oil fields in Beibuwan Basin are derived from bottom black oil shale of 2nd member of Liushagang Formation in Middle Eocene(E2l2). Most of the shale samples have present-day TOC above 2%, which have met the accepted good-excellent standard of source rocks. Vitrinite reflectance values show source rocks in the B subsag slope are staying in the early oil stage of generation. In view of stratigraphic distribution and stimulated maturities of sour rocks, E2l2 may have been matured for peak oil generation at deeper depths. Burial and hydrocarbon generation history is studied by conducting Ro calibrated 1D basin models. Analysis results show that the hydrocarbon was charged immediately after the hydrocarbon generation peak of the source rocks combining with fluid inclusion petrography, fluorescence spectroscopy and microthermometry data and was just in time for tectonic movement during late stage of Weizhou Formation in Oligocene (E2W3). Permeable sand body and fault system served as the main migration pathways. One typical cross-sections were also selected to simulate the evolution of overpressure and its effects on hydrocarbon migration. Overpressure was mainly on the middle of black oil shale in E2l2 based on the analysis of single well. 2D modeling results calibrated with measured vitrinite reflectance and permeability data indicate that the overpressure was built up as a result of quick subsidence and sedimentation rate of deep lacustrine mudstone in early Eocene (uncompacted mudstone sourcerock). The widespread low-permeability mudstone in middle E2l2 that retarded pressure transmission and fluid flow played an important role in the generation and distribution of overpressure. The build-up overpressure in the source rock intervals increase after hydrocarbon generation, therefore reopened the faults and drove the hydrocarbon vertically into the traps that are above the impermeable mudstone or below the overpressure section. Thermal subsidence of the basin after tectonic movement made the fault activity stopped, therefore oil reservoirs could be preserved.

A LOGGING IDENTIFICATION METHOD OF TIGHT OIL RESERVOIR LITHOLOGY AND LITHOFACIES: A CASE FROM MEMBER CHANG7 OF TRIASSIC YANCHANG FORMATION IN HESHUI AREA, ORDOS BASIN, NW CHINA

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Based on the observation results of hundreds of cores and the structural analysis, sedimentary microfacies analysis, lithologic analysis and other analytical tests and logging data, fine description and summary of the characteristics of lithology and lithofacies of Triassic Yanchang Formation Member Chang7 tight oil reservoir in Heshui area, Ordos basin, the criteria for identification of lithofacies by logging were established. The lithofacies in Chang7 tight oil reservoir were classified by five types: fine sandstone deposited by sandy debris flow, turbidite fine siltstone, fine sandstone deposited by slump, semi-deep to deep lacustrine mudstone, and oil shale. The lithofacies in Chang7 tight oil reservoir were characterized, both qualitatively and quantitatively, with electric logging and imaging logging and several means and methods, the response characteristics of different lithofacies were summarized through analyzing the image log and conventional log data, and the parameters characterizing sandstone's structures were used to quantitatively characterize the lithofacies, the criteria for identification of different lithofacies by logging were established. Vertical and horizontal identification and classification of lithofacies in a single well was then accomplished by processing the log data from each well, the results of lithofacies identification tally well with the results of formation testing. In-depth lithofacies analysis proves to be an important method of tight oil reservoir evaluation and "sweet-point" prediction.

THE SEDIMENTARY CHARACTERISTICS OF TERMINAL FANS SYSTEM IN 2+3 OF THE UPPER SECOND MEMBER OF SHAHEJIE FORMATION, WEST PUCHENG OILFIELD, DONGPU DEPRESSION IN BOHAI BAY BASIN

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The reservoir in 2+3 of the Upper Second Member of Shahejie Formation, West Pucheng Oilfield has high shale content, which is characterized by the development of interlayer of mudstone and mudstone in sandstone and that the interbed is frequent. The analysis of regional sedimentary background, detailed observation and description of core well, well logging facies analysis and analysis and identification of the data shows that the sand formation is terminal fans system. The depositional system is a traction flow deposit, which is a sandy deposit formed in the arid climate by the influence of percolation and evaporation and the reduction of the flow energy of the river. The provenance areas begin to develop into the proximal subfacies, the central subfacies and the distal subfacies in turn. The central subfacies is developed in the research area, followed by the distal subfacies from the provenance area. It is considered that the Pucheng area in Dongpu depression is under semi-arid climate during the deposition of the Second Member of Shahejie Formation. On the one hand, it shows that the lake level in the research area fluctuation frequently, the seasonal rainfall and the alternation of flood flow, on the other hand, it also shows the loss of flow caused by percolation, the decrease of water energy and rapid deposition of sediment, and the difference of sediment content between sand and mud. These two aspects are the main reasons for the high shale content in 2+3 of the Upper Second Member of Shahejie Formation.

DEPOSITIONAL SETTING AND DIAGENETIC PROCESSES AND THEIR IMPACT ON THE RESERVOIR QUALITY IN A CARBONATE PLATFORM: LATE SERPUKHOVIAN-EARLY MOSCOVIAN, ZHANAZHOL RESERVOIR, PRE-CASPIAN BASIN, KAZAKHSTAN

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Zhanazhol buildup, an oil-producing carbonate platform in the northeastern Precaspian Sea, contains a succession of shallow-water platforms ranging in age from late Serpukhovian to early Moscovian. The strong reservoir heterogeneity has already been its most critical influence on the reservoir development, while the impact of depositional setting and diagenetic modification on the reservoir quality in the carbonate platform is poorly understood but of paramount importance to reservoir characterization.

We classified the lithofacies, reconstructed the paragenetic sequence and assessed their impact on the reservoir quality which based on analysis of five cored wells with 266.3 m cores, integrated sedimentology, petrography, fluid inclusion, CL, stable isotopes, and trace element data.

The interval consists of several hundred meters-scale, high-frequency sequences, capped by shallow water lithofacies and based with relative deep-water lithofacies. Fourteen lithofacies were classified by depositional attributes, such as texture, grain types, sizes and sorting, sedimentary structures etc., which were clustered into three facies groups: group S, M and D, based on the interpretation of paleowater depth, hydrodynamic energy and depositional environment.

According to the result of reservoir quality analysis, high-quality reservoir developed in group M, low-quality reservoir developed in group S by intense early cementation, and group D constitutes of medium quality reservoir with low primary porosity and weak diagenetic modification.

Near surface diagenesis includes marine isopachous rim cementation, followed by meteoric dissolution, cementation and mechanical compaction. Marine cementation had a relatively major effect on pore system, and was much stronger in group S than that in other facies groups, due to the high salinity pore water as a consequence of intensive evaporation and poor circulation. Meteoric dissolution only improved the reservoir quality with moldic pores at the top of high-order sequences. Mechanical compaction had a relatively major effect in group D, due to poor early cementation and relatively low grain content.

With progressive burial, more calcite cement precipitated, and microfractures unevenly distributed in different lithofacies. Grain breakages are rich in poorly cement skeletal grainstones (group M), while early tightly cemented ooids and intraclasts grainstone (group S) shows microfractures at core scale. Pressure dissolution is significant in group D. The following dissolution, associated with organic acid expulsed from the mature organism, obviously increased the residual porosity.

There are also obvious discrepancies occurred in the group M, which is a response to the different lithofacies associations (or sequence stacking patterns) and paragenetic sequences. Thick group S in sequence, suggests that a relatively prolonged low sea level period, had a damaging impact on primary interparticle pores protection and secondary dissolution by organic acid.

SOURCE TO SINK STUDIES BETWEEN THE SHALEITIAN UPLIFT AND SURROUNDING SAGS: PERSPECTIVES ON THE IMPORTANCE OF HINTERLAND RELIEF AND CATCHMENT AREA FOR SEDIMENT BUDGET, WESTERN BOHAI BAY BASIN, CHINA

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Source-to-Sink system analysis, a cutting-edge topic of the field of earth science, encompasses the whole system from erosion, transportation to sediment accumulation on the Earth's surface and involves multi-disciplinary collaboration. This current analysis based on high-precision 3D seismic data, well logs and other drilling data, using quantitative characterization of the source to sink elements, documents that Archean Proterozoic migmatitic granite, Cambrian Ordovician carbonate and clastic rocks, Mesozoic volcani-clastic rocks are developed in the Shaleitian uplift from south to north across large relief differences (up to 2300 m). 20 catchment areas (2094 km^2) and three types of sediment transporting channel system were documented around the edges of the uplift: paleovalley channels, fault-controlled channels, and faulttransfer channels. The Paleogene sink was dominated by near-source coarse-grained depositional systems, with the lithofacies characteristics of lowstand system tract (sand rich) lake transgressive system tract (mud rich)uplift system tract (sand rich). Three types of fault-related slopes were developed in the region of the Shaleitian uplift: fault-related steepslopes (single or multiple), fault ramps, and slope type. The bedrock composition, catchment area, channel systems and fault-border patterns in Shaleitian uplift jointly controlled the types and scales of sedimentary sandbodies. The south Shaleitian tectonic zone functioned as a highefficient coupling system, where reservoir sandbodies were developed (extensive length distance, with well sorted and rounded sediments, but weak physical properties). The coupling system for the southwest and west Shaleitian tectonic zones was subordinate (near source and sand rich, sand and mud interbedded, weak physical properties). The coupling system of the northeast Shaleitian tectonic zone was lowest in efficiency (relatively mud rich).

THE EARLY CRETACEOUS DEPOSITIONAL ENVIRONMENTS IN THE BARENTS SEA; A STOCHASTIC MODELLING APPROACH IN STORM SOFTWARE

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The Barents Sea is a structurally complex area consisting of deep to shallow basins, structural platforms and highs. The area experienced tectonically-driven complex structural development during the Cretaceous including differential subsidence and uplift resulting in distinctive sedimentary environments. In this setting, the Lower Cretaceous Kolje Formation was deposited over the Barents Sea shelf as shales and claystones. Borehole data indicate that the formation thickness varies significantly from only a few to about 750 metres. In the western part of the shelf (e.g. the Hammerfest Basin) the Kolje Formation is organic rich, while in the remaining parts the formation shows a lower content of organic matter.

The aim of this study is to explain why the organic content and depositional environments of the Kolje Formation varied significantly over the shelf. In the approach taken here, that involves reconstruction of the Early Cretaceous palaeo-bathymetry, sedimentation rates and initial properties of the Kolje Formation in the western-central Barents Sea. The reconstruction is conducted by using a new Monte Carlo-based StoRM software (Stochastic Rock Modelling). The program models 1D deposition history by using semirandom sedimentological parameters for millions of modelling runs. Then it filters 'likely' runs and their parameter values by comparing the modelled deposit thickness to borehole measurements. The large number of exploration wells and available well data make the Barents Sea area ideal for conducting such a type of study.

This study will depict spatial differences of the Early Cretaceous depositional environments in a regional context and will show variations of the sediment deposition rates. Furthermore, we will present a bathymetrical model of the Barents Sea constructed with the use of the constrained sedimentation rates and Airy isostasy. By combining the sedimentation rates and the palaeo-bathymetry we will provide a spatial model of the Kolje Formation in the Barents Sea and the possible influence on organic richness.

SEISMIC GEOMORPHOLOGY LINKED TO SEQUENCE STRATIGRAPHY OF AN EOCENE DELTA IN THE OUTER MORAY FIRTH, UKCS

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Clinothems are a key component of shallow marine systems. Controls on bed dip and how they taper include type of delta, the location of the sediment input points, the grainsize and proportion of fine grained cohesive sediment within the system and the shoreline trajectory. The true 3D nature of clinothem geometry is difficult to accurately quantify in outcrop studies which at best provide a 2.5D section.

The shallow, high frequency component of traditional 3D seismic data is a massively underused resource of high quality geometric data that can be used to study depositional systems. It provides 3D information that is not available from the 2D plan-view data from modern systems or the cross section view typically provided by outcrop analogues. We use such data to undertake a case study on the Mousa Delta, a Paleogene shallow marine succession from the Outer Moray Firth, UKCS. The package has been mapped and a series of geomorphological properties (e.g., clinoform, dip, bed taper, width, length) as well as the shoreline trajectory have been determined. Mapping was initially undertaken manually, then an automated interpretation software was used to produce very large volumes of data.

The data suggest that the Mousa Delta is a prograding wave dominated delta which includes both normal and forced regressive components. Clinoform dip increases from 1.4 during initial transgression to 4.7 during forced regression. This is due to successive stacking of the clinothems. The rate at which the beds taper shows a parallel trend. Along strike clinoform dip shows significant variations of up to 6. Additional analysis of well data showed that the highest clinoform dips coincide with a coarse grained lithology containing a high amount of lithic fragments. These deposits are interpreted as the remnants of feeder channels controlling clinoform dip distribution.

With the identified trends it is possible to infer the distribution of coarse grained sediments within a regressive deltaic system. The variability of clinoform, dip strike also highlights that measurements are position-sensitive which needs to be taken into account in outcrop studies. Bed taper is verified as a useful characteristic of clinothems independently confirming trends identified in clinoform dip.

SEDIMENTARY PROVENANCE IN THE BANDA ARC: IMPLICATIONS FOR TECTONIC EVOLUTION BASED ON HEAVY MINERALS AND ZIRCON GEOCHRONOLOGY

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Sandstones in the Outer Banda Arc Islands (Indonesia) are thought to be the equivalent of Mesozoic sandstones on the Australian margin. They have been exposed by on-going collision resulting in the opportunity to study their provenance. Previous studies suggest that rivers draining Australia will have provided most sedimentary input and there have been suggestions of a northern provenance for some Timor sediments.

This provenance study of Triassic, Jurassic and Cretaceous siliciclastic sediments in the Banda Arc between Timor and Tanimbar used several methodologies, including conventional light and heavy mineral point-counting, textural classification, and laser ablation (LA-ICP-MS) U-Pb dating of detrital zircons. Results show a number of new and some surprising features for the geological formations analysed. Most sandstones are quartz-rich and detrital modes suggest a recycled origin and/or continental affinity, consistent with an Australian source. However, many of the sandstones are texturally immature and contain volcanic quartz and volcanic lithic fragments. Mixing of contemporaneous acidic igneous, recycled sedimentary and metamorphic rock sources are suggested.

In the Tanimbar Islands and Babar, acid igneous material came from both the Australian continent and from the Bird's Head as a newly identified source of Permian and Triassic volcanic debris. The Bird's Head component diminishes westwards. Sandstones in Timor in comparison have a greater metamorphic component. Heavy mineral assemblages are dominated by rounded ultra-stable minerals, but mixed with angular grains, and indicate an ultimate origin from acid igneous and metamorphic sources. Detrital zircon ages range from Archean to Mesozoic, but variations in age populations point to differences in source areas along the Banda Arc both spatially and temporally. Significant zircon populations with ages of 240-280 Ma, 1.5 Ga and 1.8 Ga are characteristic and are also common in many other areas of SE Asia.

We interpret sediment to have been derived in the Triassic mainly from the Bird's Head, Western and Central Australia. In the Jurassic, local sources close to Timor are suggested, combined with recycling of NW Shelf material. Zircon populations in Cretaceous sandstones suggest that they were derived from the Schwaner Mountains in Borneo. A new palaeogeographic and tectonic model is proposed to explain the dynamic evolution and history of some of these island fragments.

TRACING SAND PROVENANCE RESILIENCE OF PROVENANCE SIGNALS IN THE SUBSURFACE

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Conventional bulk-rock analyses, heavy mineral studies and single-grain geochronology are powerful and well-established tools in provenance and sediment tracking studies. However, these methods struggle with apportioning volumes contributed from different sources and unravelling possible grain recycling.

K-feldspar is likely to be preserved over long transport distances and its common Pb isotopic composition can be linked to immediate sources. It can therefore provide additional insight alongside other provenance tools in terms of the ultimate source of the sand fraction and the relative contributions from different parts of the drainage basin. It is less likely to be biased by recycling and multiple phases of storage which can be an issue when using zircon geochronology alone.

However, K-feldspar is affected by burial and diagenesis, especially when exposed to pore fluids that dissolve the grains with increasing depth, to the extent that the overall framework composition may be significantly modified. Previous work has implied that arkoses may become quartz arenites with depth implying possible purging of the provenance signal.

The Jurassic Fulmar Formation in the Central North Sea is a well-studied arkosic sandstone with excellent reservoir properties. Thick successions of commonly highly bioturbated shallow-marine sands were buried to a range of depths between 3.2 and 6 km depending on position relative to the basin margin. Typical diagenetic features of deep burial are highlighted by SEM imaging, showing increasing feldspar alteration and replacement at depth. Reactions include early dissolution and authigenic quartz, feldspar and ankerite overgrowths. Primary porosity is affected by micro-quartz cementation and carbonate cement redistribution, and secondary porosity by feldspar dissolution with increasing depth.

Given the presence of dissolution features, the key question investigated here is the resilience of the provenance signal. Pb isotope analyses indicate two main provenance domains for the Fulmar Formation, one with a $^{206}Pb/^{204}Pb$ ratio of 17.0-17.25 and one with $^{206}Pb/204Pb$ between 18.0-18.5. Results indicate similar proportions of the two populations at depths of ~3.2 km, ~4.3 km, ~5.4 km and ~5.7 km. This information is critical for future work and integration in projects that include the Pb in K-feldspar method in multi-proxy provenance approach, especially when dealing with subsurface samples or recycled sediments.

MODELLING THE SEQUENCE STRATIGRAPHIC DEVELOPMENT OF THE UPPER JURASSIC CURTIS FORMATION ALONG THE NE MARGIN OF THE SAN RAFAEL SWELL, CENTRAL-EASTERN UTAH, USA: ANEXAMPLE OF A LOW-GRADIENT TIDAL BASIN

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This study focuses on the Middle and Upper Jurassic Entrada-Curtis-Summerville formations, following a 60 km north-south trending escarpment on the north-eastern margin of the San Rafael Swell, Central-Eastern Utah, USA. Based on sedimentary facies analysis and application of sequence stratigraphic principles, a reconstruction of depositional environments emphasises the highly dynamic interactions between depositional processes in low-gradient tidal basins. Intricate lateral and vertical distribution of facies is mapped, and correlation is linked to key sequence stratigraphic surfaces of regional significance. The collected data and its interpretation sustains that (i) the regional J-3 Unconformity displays evidence of preand syn-Curtis Formation erosional episodes, carving down ca. 15 m into the underlying strata of the Entrada Sandstone. (ii) Laterally restricted shoreface deposits, formed in topographic lows, represent the first stage of the Curtis Sea transgression over the Entrada Sandstone. (iii) The transgression of the Curtis Sea occurred in a backstepping manner, with the subsequent deposition of three coarsening-up parasequences, mainly consisting of subtidal mudand sand-dominated heterolithic deposits. (iv) Several episodes of relative sea-level variations, possibly linked to glacio-eustatic processes, occurred during the transgressive phase, leading to the development of a proximal, sand-dominated subto supratidal flat in the south and its correlative distal subtidal, multi-incised channels in the north. (v) The transgression reached its maximum extent with the deposition of sand-dominated high-energy tidal channels and bar complexes, which protected the backbarrier intertidal mix-flat. (vi) Suband intertidal strata represent an initial period of architectural aggradation, succeeded by the early stage of a prograding supratidal coastline during highstand. This study has shown that a sequence stratigraphic approach over a complex low-gradient tide-dominated basin is successful in correlating the highly heterolithic measured sections, as well as linking the development of such deposits to a relative base level history through the careful identification of the following sequence stratigraphic surfaces: flooding surfaces, tidal ravinement surfaces and regressive surfaces of marine erosion. It further enhances that facies distribution prediction still remain highly uncertain in such a complex low-gradient tide-dominated system.

INTEGRATED STRATIGRAPHY OF A KIMMERIDGIAN CARBONATE RAMP SETTING (LOWER SAXONY BASIN, NORTHERN GERMANY): COMBINING SEDIMENTOLOGY, SEQUENCE-, CHEMO- AND BIO-STRATIGRAPHY

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Deposited during a time of global warmth, the Kimmeridgian (Late Jurassic) successions of the Lower Saxony Basin in northern Germany are represented by alternating limestones, marls and claystones, which have been interpreted to be the shallow marine product of a gently dipping carbonate ramp. Up to now, stratigraphic uncertainties caused by the absence of open marine marker fossils and prevalence of sedimentary gaps did hamper further study of these strata. Here, an integrated analysis is presented combining sedimentology, sequence stratigraphy, chemostratigraphy and biostratigraphy of three Kimmeridgian sections (Langenberg, Bisperode and Potzen) located in the eastern part of the Lower Saxony Basin. The study aims at providing novel insights into the sedimentary environment, stratigraphic framework and paleoclimate evolution of the Late Jurassic Lower Saxony Basin. The Kimmeridgian successions are composed of 19 microfacies types, which are arranged into seven facies belts covering innerto mid-ramp settings. Two hierarchies of sequences (shortand long-term) are identified based on vertical stacking patterns, changes in allochem composition, grain size and bed thickness as well as diagnostic surfaces. Sections are dated using ostracod biostratigraphy combined with high-resolution bulk rock carbon-isotope and low-Mg calcite (brachiopods, oysters and Trichites bivalves) strontium-isotope ($^{87}Sr/^{86}Sr$) stratigraphy. An increasing trend in $^{87}Sr/^{86}Sr$ with stratigraphic height fits well with the global strontium-isotope curve, indicating an Early to early Late Kimmeridgian age of the studied deposits, which is in accordance with ostracod biostratigraphic data. Based on this chronostratigraphic framework, identified long-term sequences can be correlated on a basin-wide scale. Oxygen-isotope data recorded by the best-preserved low-Mg calcite shells are used to reconstruct shallow-water sea-surface temperatures during the Kimmeridgian, which are compared with contemporaneous temperature estimates from other European Basins.

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