Porosity Characterization and Flow Units Identification of the Upper Khartam Member, Khuff Formation (Permian-Triassic): Outcrop Approach, Central Saudi Arabia

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The study investigates the porosity and flow units' characteristics of the Permian-Triassic Upper Khartam Member of the Khuff Formation, in At Tarafiyah area, Qasim region, central Saudi Arabia. The objectives of this study are: to identify the geometrical characteristics for each pore type and subdivide the individual pore type based on their geometries, assess the flow units according to their porosity-permeability and their reservoir quality index (RQI) at the outcrop scale. Thin section petrography was used to identify the different types of porosity and the diagenetic alterations that may affect the porosity. The pore sizes, aspect ratio, roundness factor, and frequencies were determined for each pore type using Petrographic Image Analysis (PIA) technique. Microporosity in the investigated samples was identified with the aid of scanning electron microscopy microscope (SEM). Core plugs' poroiometer and permeameter were used to get measure the total porosity and the permeability. The outcrop succession is mainly composited of well-sorted oolitic grainstone, cross-bedded oolitic skeletal grainstone and graded mudstone to packstone facies. Based on the thin section studies, moldic porosity is classified geometrically into oomoldic and skelmoldic porosities. Similarly, vuggy porosity shows two different geometrical-sizes that are called vuggy-1 and vuggy-2. Moreover, the porosity types are ranked based on their sizes into eight different classes. Oomoldic and vuggy-1 have the best ranking classes, while intracrystalline and intragranular porosities have the worst ranking classes. The combination of oomoldic and vuggy-1 form the optimum reservoir quality. Integration of the (RQI), core porosity-permeability values and outcrop lithofacies shows detailed petrophysical behavior of the flow units laterally and vertically.

Spatial distribution of the 2011 Tohoku-oki tsunami deposits in a narrow valley at the southern end of Sendai Plain

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This study focuses on spatial sedimentary process of the 2011 Tohoku-oki tsunami in a narrow valley at the south end of the Sendai Plain. Previous researches have tended to study tsunami deposits along transect line(s). However, tsunami flow is complex due to local topography and as such a broader spatial distribution should be investigated. In this study, we investigated tsunami deposits at 176 sites within a narrow valley and analyzed thickness, grain size, sedimentary structures. We examined elevation data and aerial photographs of before and after tsunami. In addition to, we analyzed the grain size distributions of the sandy deposit and diatom assemblages of the muddy deposit.

The main valley stretched east to west with 2.4 km long and some sub-valleys stretched south to north with 10 meters to 100 m and surrounded by the high terraces. A small pond is located in a wetland at distances of 0.7-0.9 km from the coastline. The tsunami reached 2.2 km from the coastline and ran up to 11.6 m at the valley head. The average tsunami directions of up flow, estimated from orientation of the knocked-down tress, suggest that main direction of tsunami inflow was westward. On the other hand, return flow was complex on the basis of distribution of debris and shape of erosional features formed by backwash.

The sandy tsunami deposits were ranged in thickness up to 40 cm. Sand beach and sand dune were fairly eroded by the tsunami flow and may supply inland a plenty amount of sand. Grain size distributions were similar among the tsunami sand, beach sand and dune sand. As for tsunami deposits, sand thickness generally decreased inland, but they were spatially fluctuating associated with slope, topographic features and artificial structures. The muddy tsunami deposits were ranged in thickness up to 40 cm. Paddy field and bottom of the pond were eroded by the tsunami flow. In consequence of a mud transport from the pond, mud thickness rapidly increased around the pond. Diatom assembles suggest that muddy tsunami deposit sourced from the pond bottom sediments and rice paddy soil. In the sub-valley area and upper main valley area with higher than 3 m in elevation, the sand thickness became thinner with increasing in elevation and the sand layer was mostly composed of single unit. On the other hand, in the lower main valley area with lower than 3 m in elevation, the sand thickness was less influenced by elevation and the sand layer was mostly composed of 2-5 units. The number of sub-unit might be related to the tsunami wave number in this valley. Therefore, it is probably that at least 5 waves inundated over the lowland with lower than 3 m in elevation. We concluded that the change of tsunami hydrodynamic processes at the slope change point trigger characteristic thickness distribution and sedimentary processes. Besides, we estimated that the depositional volume of the sand was enough to be explained by erosional volume of beach and dune sand, and more than half of the erosional volume discharge into the sea by the return flow. Depositional volume of the mud was also sufficient amount for erosional volume of land and pond. We concluded that the tsunami deposits in this valley were mostly sourced from land and the pond.

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Can petrographic fabric analysis be used as a tool to recognised supercritical-flow bedforms in cores? An outcrop case study from a Late Carboniferous deltaic setting

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Reservoir characterisation is often based on integrated studies of few to several tools such as seismic profiles, wireline logs, borehole image, core observations and petrography. Typically these tools provide either information about the regional architecture of the reservoir like seismic data does or the data is limited to a vertical section on a single point like core data. This relatively large gap in scale of the various data sources result in a lack of data on a meter to tens of meter scale. Outcrop studies, where available, provide valuable data; and upscaling/downscaling of the information obtained from outcrops can fill the gap between the seismic and core scale.

Recent flume experiments and direct submarine observations of turbidity currents on delta channels have increased our knowledge about their flow dynamics and sediment deposition processes. One of the outcomes of these studies is that supercritical-flow bedforms are far more abundant than was previously thought. Initial experimental results indicate that the deposits left behind by these supercritical-flow bedforms consist of aggradational backset packages composed of mainly structureless to crudely stratified sandstones. In one such backset, various bed-scale fabrics are likely to occur due to changes in flow characteristics and associated sediment transport processes over the stoss side of these bedforms. These cyclic steps are typically in a sub-seismic scale, yet they are very difficult to recognise in core. Better understanding of downstream facies and thereby formed vertical stacking pattern of bed-scale fabrics seems to be the key to recognise supercritical-flow bedforms like cyclic steps in cores.

In this study, we aimed to link outcrop-scale properties of cyclic steps to core and micro-scale features of bed-scale fabrics in order to be make an attempt to use petrography as a tool for recognition of bed-scale fabrics and hence the cyclic steps in core. Additionally, detail and micro-scale characterisation of various bed-scale fabrics of cyclic steps can be used as a reservoir quality prediction tool in future studies.

For this case study, outcrops of Late Carboniferous sandstones of the Lower Kinderscout Grit, that were deposited in fluvio-deltaic to shallow-marine setting has been selected. The outcrop study was carried out in the Derby Delph Quarry (near the Booth Wood Reservoir, Rishworth, West Yorkshire) which comprises sets of large-scale (10s of meters in wavelength), undulating sandstone beds. These sandstones are typically massive, poorly to very poorly sorted and predominantly ungraded. In the main quarry wall, four aggradational bedsets, separated by distinct erosive surfaces are recognised. Preliminary petrographical studies on various transects throughout the bedsets of Derby Delph Quarry yielded promising result on possibility of using petrography as a tool for cyclic step recognition in cores.

The sedimentary and paleoenvironmental expression of mass extinctions, where do we stand?

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Main mass extinctions in the Phanerozoic are almost always related with severe climate changes and large sea-level fluctuations. Over the last 30 years considerable research efforts have been directed toward understanding the context and nature of environmental changes that occurred immediately prior to, at, and after the five major Phanerozoic mass extinctions. Actually, earth volcanic activity linked to LIPS is one of the two leading scenarios proposed to explain the pattern of mass extinctions in the Phanerozoic, the other involving asteroid impacts. The consistent association of large magmatic provinces (LIPs and CFBPs) with all but one (end-Ordovician) of the five major Phanerozoic mass extinctions implies that volcanism played a major role. Faunal and geochemical evidence from the end-Permian, end-Devonian, end-Cretaceous and Triassic/Jurassic transition suggests that the biotic stress was due to a lethal combination of tectonically induced hydrothermal and volcanic processes, leading to eutrophication in the oceans, global warming, sea level transgression and oceanic anoxia. Evidence of regression giving rise to a shallowing-upward succession quickly followed by transgression marked by the widespread deposition of black shales are well established for all the five major Phanerozoic extinctions, with the exception of the Cretaceous- Tertiary boundary (KTB) one. If a rising sea level marks also the uppermost Maastrichtian leading to the deposition of a condensed interval at the KTB, however black shales deposits remain quite rare. Their absence is probably linked to more dynamic paleooceanographic conditions linked to increased paleolatitudinal gradient, which prevailed since the mid-Maastrichtian cooling events.

Major magmatic events and their long-term environmental consequences are the main contributors, though not the sole causes of mass extinctions. Sudden mass extinctions, such as at the K/T boundary, may require the coincidence of major volcanism and a very large impact. Mass extinction is therefore the culmination of many factors, which contributed to high-stress environmental conditions, including long-term perturbations (volcanism, e.g. Deccan traps for the end-Cretaceous, cooling, sea-level fluctuations) and short terms events (impacts). No single kill mechanism can really be identified.

Carbonate rhizoliths: from morphology to metabolism

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Rhizoliths, i.e., traces and remains of plant roots preserved in mineral matter, most commonly composed of calcium carbonate, are among the most prominent features of paleosurfaces and may constitute the dominant fabrics in some forms of calcretes. However, except for their gross morphology, even the typical macroscopic rhizoliths may show no biologically influenced carbonate fabrics. Moreover, many forms of secondary carbonate in soils and palaeosols which are considered rhizogenic (implying direct or indirect role of live plant roots in $CaCO_3$ precipitation) actually show no or very limited conclusive evidence of biogenicity. Macroscopic rhizoliths (cm to m scale) can be the most obvious in outcrops but have only a minor significance for the understanding of the carbonate precipitation mechanisms. Large rhizoliths correspond to parts of a coarse root system, comprised of lower order roots, which are responsible for mechanical support and the transport of substances between the soil and the shoot. In both annual and perennial plants, the dominant component of the root system is a structurally and functionally complex population of fine roots, <1-2 mm in diameter, which are responsible for the water and nutrient uptake, as well as mycorrhizae formation. Fine roots have short lifespan (days-months), but are replaced by the plant in a continuing process of root 'turnover'. A narrow zone surrounding fine roots where soil properties and microbial populations are influenced by root exudates, is called rhizosphere. Very large reactive surface area of fine root systems per soil volume indicates the crucial role of the rhizosphere in near-surface precipitation terrestrial carbonates. Ion exchange processes between fine roots and solid soil phases can result in carbonate biomineralisation in- or around fine roots. $CaCO_3$ precipitation in the rhizosphere is mediated mainly by the root-associated microorganisms in the soil (fungi and bacteria). Significant accumulations of secondary carbonate in soils and palaeosols are formed through biologically induced $CaCO_3$ mineralisation in cortical cells of fine roots. Intracellular calcification, coupled with extrusion of protons, most probably represents an effective nutrient acquisition mechanism. Processes and products of root-influenced carbonate biomineralisation will be shown using Holocene and Pleistocene examples of laminar calcretes from San Salvador and North Andros (Bahamas), Florida Keys, and calcified roots from Pleistocene and modern soils of Spain (the Alicante region and the Island of Mallorca). Well-documented Quaternary examples will be compared with possible analogues in carbonate sequences in the rock record.

Formation of ironstone crusts in the Cenomanian deposits of the Bahariya Depression, Western Desert, Egypt – Environmentally or diagenetically constrained?

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Ironstone crusts are prominent throughout the lower and upper members, though absent in the middle member, of the Cenomanian Bahariya Formation, north of the Bahariya Depression. This stratigraphic formation is mainly composed of siliciclastic rocks, i.e. cross-bedded and massive sandstone, siltstone, variegated shale and fossiliferous sandstone/sandy limestone. Dark bituminous-rich sandstones occur in the middle member of the formation. Full understanding of the Bahariya ironstones requires not only a clear description and interpretation of sedimentary facies but also the paragenetic mineral sequence forming the ironstones and their host siliciclastic rocks.

Field sedimentological work, XRD mineral determinations, standard petrography and SEM and electron microprobe (EMPA) analyses indicate that the ironstones are composed of a variety of diagenetic minerals formed throughout eo-, meso-, and telodiagenetic stages. New mineral phases formed during early diagenesis, i.e. siderite, barite, Mn-minerals and goethite coatings, are volumetrically less important than those produced during burial and later telodiagenetic stage. These latter diagenetic products comprise Fe-dolomite/ankerite, bitumen, silica/feldspar overgrowths and high amount (up to 65%) of iron oxyhydroxides. During burial, dolomite and ankerite replaced preferentially micrite matrix, bioclasts and several calcrete features as well as infilled vugs. Also during the mesodiagenesis, the decomposition of organic matter resulted in the formation of bitumen and created reducing conditions favourable for the mobilization of iron-rich fluids in divalent stage.

Telodiagenesis of the Cenomanian Bahariya deposits took place during the Turonian-Santonian. Uplift resulted in partial to total dissolution of the Fe-dolomites and subsequent precipitation of iron oxyhydroxides. The preservation of large centers and clear rims with no collapse features of the Fe-dolomites implies alteration by solution. Fe-dolomite and ankerite dissolution was concomitant to iron oxyhydroxide precipitation upon mixing with shallow oxygenated water.

Source of iron for the ironstone crusts of the Bahariya Formation has been debated and various formative sources have been proposed. These include alteration of clay minerals and heavy minerals, extensive weathering of older rocks and further transport of iron in solution or as colloid, whether in the sediment load or by groundwater inflow, etcetera. Circulation of reducing iron-rich fluids through fractures and inter and intrastratal discontinuities is proposed as an alternative model. The origin of iron-rich fluids is probably related to basement rocks but contribution from other underlying formations of Paleozoic, Jurassic or earlier Cretaceous in age is not excluded. This model explains better the lateral continuity and heterogeneous geometries of the ironstones in Bahariya, which are related to main faults in the area.

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Late stage diagenetic alterations in Turonian- Maastrichtian Kawagarh Formation, Hazara Basin (NW Lesser Himalayas, Pakistan): Based on petrographic, geochemical and stable isotopic information

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The Kawagarh Formation is dominantly composed of limestone with subordinate dolomite and marl. It was deposited in warm tropical homoclinal ramp settings at 23˚S latitude when the Indian Peninsula collided with the Kohistan Island Arc at ca. 65 Ma. The present study involves detailed sampling of eight stratigraphic sections, petrographic analysis (n=880), XRD (n=15), major (Ca and Mg) and minor (Sr, Na, Mn and Fe) trace element geochemistry (n=110), and stable isotopic ($\delta^{18}O$ and $\delta^{13}C$) signatures (n=32).

The petrographic studies demonstrate that Kawagarh Formation has been subjected to complex diagenetic history including compaction, minor dripstone, meniscus cementation and dolomitization. Close packing of grains, point contacts, dissolution seams and stylolites indicate effects of both mechanical and chemical compaction. Mostly dissolution seams are parallel to bedding and may have dolomite or clays.

Stable isotope analyses indicate depleted $\delta^{18}O$ signatures (-3.70 to -7.81‰ PDB) of the host limestones that points to readjustment due to fluid interaction. In case of dolomite, depleted $\delta^{18}O$ values (-3.22 to -7.28‰ PDB) indicate interaction of relatively warm Mg- rich fluids with the host limestone. Besides this, $\delta^{13}C$ values (-3.95 to +2.88‰ PDB) suggest late stage (meteoric) calcitization/dedolomitization process. Nearly comparable average trace elements (Sr, Na, Mn and Fe) in limestone and dolomite indicate a same source i.e. limestones of mixed mineralogy were modified in meteoric realm. Moreover, covariant trend perceived in compositions of oxygen and carbon isotopes proposes influence of meteoric diagenesis. Various plots of the trace elements with $\delta^{18}O$ and $\delta^{13}C$ show mixing between marine and meteoric waters. This fact is further substantiated by loss of Sr and Na, and enrichment in Mn and Fe. Ambient sea surface temperature of about 27°C to 33°C is assessed for warm tropical waters to deposit the sediments.

In conclusion, depletion in $\delta^{18}O$ and $\delta^{13}C$ as well as Sr and Na and elevated Fe and Mn content confer interaction of relatively hot dolomitizing fluids, followed by meteoric diagenesis.

Palaeo-environmental reconstructions of the non-marine Lower Cretaceous English Wealden: New Insights from Petrographic, Geochemical and Siderite analyses

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Palaeo-environmental reconstructions of the fluvial Wealden strata in southeast England have been based mainly on field, fossil and mineralogical data. We present new insights into the palaeo-depositional environments of these Lower Cretaceous sediments based on the analyses of petrographic, geochemical and siderite data. Field and mineralogical data also supplemented these interpretations.

Petrographic analyses show that the Wealden sandstones are mainly quartz arenites which originated from a stable continental margin and from low-lying massifs that are characterized by arid/semi-arid climate. Their rounded shapes and texture which show their maturity demonstrate that the sediments have travelled reasonably long distance prior to deposition.

Elemental composition of widespread early diagenetic siderites confirmed the fresh water, non-marine origin of these sediments and provided information about low sea level and non-acidic pH levels in the Wealden times. Geochemical data confirmed felsic igneous sources for these sediments and revealed anoxic and reducing conditions. These new data sets complement existing interpretations on the palaeo-depositional environments of the Wealden sediments.

Late Quaternary fluvial and aeolian interaction, Skeleton Coast, northern Namibia

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The Skeleton Coast dune field (erg) of the Atlantic coastline of NW Namibia forms a ~300 km-long and 6 to 22 km-wide, north-northwest trending zone of active aeolian construction and accumulation that covers a 2000 km^2 region within which bed-forms of various morphological types are present and attain heights up to 50 m. The climate of the Skeleton Coast erg is hyper-arid with less than 50 mm average annual rainfall. Although the network of dunes forms a major obstacle to fluvial flow, several ephemeral rivers drain south-southwestwards through the erg towards the Atlantic Ocean. Aeolian dunes are composed predominantly of large isolated barchan forms and chains of transverse, barchanoid forms that coalesce as compound crescentic dunes, most of which are actively migrating northwards. Significant and regionally extensive flood events have been recorded in 1934, 1982, 1984, 1988, 1995, 1997 and 2000. Fluvial systems are ephemeral and undertake marked changes in discharge in response to seasonal monsoonal rainfall events in their continental-interior catchments; they are characterized by networks of shallow braided channels with longitudinal sand bars. During major flood events, rapid rises to peak discharge result in channel breaching and widespread flooding into adjacent interdune depressions at the eastern erg margin. Flood waters inundate low-lying interdune areas adjacent to the main river courses at points where fluvial systems pass into the erg along open corridors between dunes, leaving deposits of gravel, sand and silt, which are draped by clay-prone mud layers up to 15 cm thick that represent waning-stage flood deposits. Ponded flood waters within interdunes evaporates and infiltrates to leave deposits of thin beds of cohesive mud that tend to resist aeolian reworking and accumulate progressively over multiple floods. Data from the Hoanib, Hunkab and Uniab rivers, which pass through the erg, document spatial changes in the morphology of aeolian dunes and interdunes that are present in close proximity to the rivers. Geomorphological relationships have been examined through analysis of high-resolution satellite imagery data from Google Earth Pro software and quantitative data relating to the geometry, orientation and morphology of 1400 dunes and 800 interdunes have been recorded to demonstrate systematic changes with increasing proximity to the major river courses. Along the eastern erg margin, episodic damming of Hoanib River results in the development of an extensive flood reservoir basin ponded behind a dune wall. Once the water level within the basin attains a critical level it floods into the erg interior via so-called dune break-through at points where dune cols are overtopped. Floods of the Uniab River penetrate into the erg, passing through the dune field along a long-lived breakthrough corridor that runs between adjacent barchanoid dunes. The Hunkab River interacts with the erg system in a different manner; the main flood channel is commonly completely dammed by dune walls at the eastern erg margin because limited fluvial discharge events emanating from catchments of restricted area are typically insufficient to breach into the erg.

Results serve as the basis for the development of a series of predictive models that can be used to predict likely preserved stratigraphic style in aeolian dune-field margins that are subject to repeated fluvial incursions. A major outcome of this work is the construction of a series of quantitative facies models that can be used to assess likely subsurface prospectively in mixed fluvial-aeolian reservoir successions that range from aeolian dominated inner erg-margin settings to fluvial dominated outer erg-margin settings.

Human Activities on the Shores of Kuwait and Its Environmental Impact on Beaches Ecosystems and Economy

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The Arabian Gulf is a 1000 km long and 200-300 km wide open shelf in an arid subtropical area, with an average overall depth of about 35 m. Maximum depth at 100 m occurs along the Iranian coast. Kuwait is situated on the northwestern shore of the Arabian Gulf. Normally the beaches along Kuwait coasts are exposed to the strong northwesterly winds (The Shamal Winds) and the southeasterly winds (Kose Winds). The long shore currents travel southward along the shores of Kuwait after circling anti-clock wise following interring the Gulf from the Strait of Hormuz. The shores of Kuwait can be divided into three sedimentological zones. 1) The northern-coastal zone which starts from Warba Island up to Al-Salmiya, are mainly mudflats compoed of fine sands, silt and clays which are brought as suspension sediments with the long shore currents from the north. These sediments are part of the terrigenous load of the rivers Tigress and Euphrates. 2) The middle-coastal zone which starts after Al-Salmiya and ends at Mina Abd Allah between Al Fahaiheel and Al-Julaia'a, I composed of sand and some granules resulting from erosion by waves of the pre-existing beach rocks and landfill compounds. 3) The southern-coastal zone starts from Mina Abd Allah and ends at Ras Al-Himarah (the southern border with Saudi Arabia). The southern beaches are the only carbonate beaches in Kuwait and composed of oolitic sand and carbonate mud.

Human activates along the shores of Kuwait raised up many problems including environmental or economical issues which have an impact on life in this region. Most of the coastal projects that were constructed by Kuwait Government did not take into account the fragile beach environment. The majority of these problems are due to the discharging of tertiary water (treated sewage water) from more than thirty outlets along the shores of Kuwait which caused an increase of pollution level in the water. This is evidenced, e.g., by blooming of algae in some seasons indicative of the increased pollution level in sea-water along the coasts. The second factor is the landfill of the shores and establishments of the Water-front Project which affected the beaches ecosystems. The third is the disturbance of water currents by: building groins, new beach resorts along the shores, and dredging the natural and artificial sea-water channels. The construction of cement groins and wave repellant should conducted after careful scientific study of the environment to prevent future problems. The main problem is the formation of precipitation (accumulation) versus erosion areas on both sides of the cement groins that started to affect the life and economy of some coastal areas. The building of coastal resorts, especially in the Al Khiran area-south of Kuwait, were constructed on carbonate sabkhas and by creating artificial channels fed by seawater. This extraordinary and huge project has already affected the water currents circulation and both desert and coastal environments, and will raise more environmental issues in the near future.

This research is based on yearly observations during fieldtrips to the affected areas since 2001, comparing land sat images through time, and petrographic study of beach sediments.

A classification scheme for styles of fluvial-aeolian system interaction in modern and ancient dune-field margin settings

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Desert dune fields are not necessarily continuously covered with active aeolian bedforms; most additionally include other morphological bodies of aeolian-derived or aeolian-related sediment deposits including interdunes, sand sheets, soils, lacustrine systems, and perennial, intermittent or ephemeral fluvial systems developed between active aeolian dunes, especially at dune-field margins. A diverse range of styles of system interaction gives rise to considerable complexity in terms of geomorphology, sedimentology and preserved stratigraphy. Aeolian-fluvial interactions govern the extent, shape and form of the boundaries of individual dune fields. In dryland settings, recycling of sediment via both fluvial and aeolian processes over multiple erosion and deposition episodes is common, meaning that establishment of robust criteria for distinguishing between deposits of fluvial versus aeolian origin can be problematic. This study proposes a generalised framework with which to account for the diverse styles of interaction known to exist between aeolian and fluvial depositional systems. Specific objectives of this study are to: (i) illustrate the variety of styles of aeolian fluvial interaction present in modern dune-field margin settings and analogous ancient preserved outcrop and subsurface successions; (ii) demonstrate the significance of aeolian dune type and orientation relative to fluvial-system orientation in determining the style of fluvial incursion into dune fields; (iii) demonstrate the role played by open versus closed interdune corridors in controlling the distance and style of penetration of fluvial systems into dune fields.

A database recording the temporal and spatial scales over which aeolian and fluvial events operate and interact in a range of present-day and ancient desert-margin settings has been collated using high-resolution satellite imagery, and field observation. Ten distinct styles of fluvial-aeolian interaction are recognised: fluvial incursions aligned parallel to the trend of linear chains of aeolian dune forms; fluvial incursions oriented perpendicular to the trend of aeolian dunes; bifurcation of fluvial systems around aeolian dunes; through-going fluvial channel networks that cross entire aeolian dune fields; flooding of dune fields due to regionally elevated water-table levels associated with fluvial floods; fluvial incursions emanating from a single point source into dune fields; incursions emanating from multiple sheet (line) sources; cessation of the encroachment of entire aeolian dune fields by fluvial systems; termination of fluvial channel networks into playas within aeolian dune fields; long-lived versus short-lived styles of fluvial incursion.

The physical boundaries between the geomorphic systems are dynamic over short temporal timescales. Across desert margins, where fluvial and aeolian systems interact, the location of assemblages of surface landforms may change gradationally or abruptly and this governs the preserved architectural expression of facies units in ancient successions. The varied range of temporal and spatial scales over which aeolian-fluvial processes interact means that simple generalised models for the classification of styles of interaction must be applied with caution when interpreting ancient preserved successions, especially those known only from outcrop and the subsurface. By understanding the nature and surface expression of various styles of aeolian and fluvial interaction and by considering their resultant sedimentological expression and mechanisms of accumulation, predictions can be made about how the preserved deposits of such interactions might be recognised in the ancient stratigraphic record.

Palaeoenvironmental controls and ichnotaxonomy of insect trace fossil occurrences in the Miocene continental deposits of the Calatayud-Daroca Basin, Zaragoza, Spain

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A great effort has been devoted to the study of different continental ichnofacies and their palaeoenvironments. Insect trace fossils, dominated by wasp, bee and beetle traces, are characteristic of continental carbonates deposited in environments with scarce plant coverage and arid to semi-arid climates and are mostly included in the *Celliforma* Ichnofacies. In this contribution we describe abundant trace fossils recorded for the first time from the continental mudflat deposits of the Miocene of Orera area, in the Calatayud-Daroca Basin. Our aims are to describe and provide an ichnotaxonomical arrangement for the trace fossils occurring there, to determine the sedimentary controls for the presence and/or preservation of trace fossils and to point out the utility of insect trace fossils as paleoenvironmental indicators in continental deposits.

The Miocene continental deposits in the Orera area of the Calatayud-Daroca Basin are made up of cyclic sequences formed by red and brown mudstones, sepiolite and dolomicrites deposited in periodically desiccated shallow lakes, whereas mudstones with platy-like carbonates were deposited in wet-mudflat areas. Two different ichnospecies of insect trace fossils, *Fictovichnus gobiensis* and *Fictovichnus isp*. nov. were found. *Fictovichnus gobiensis,* are 15–18 mm long, 8–9 mm wide ellipsoid casts of smooth surface. One of the ends of specimens is rounded, whereas the other shows a truncated tunnel. Some of the specimens show an outer micritic layer. They are attributed to coleopteran pupation chambers. In contrast, one end of *Fictovichnus isp*. nov. is rounded and the other pointed. This ichnospecies is attributed to wasp, possibly sphecid or pompilid, coccons. Its holotype is 26 mm long and 9 mm wide. Contact with the matrix is composed of two micritic layers; possibly they are remains of the original silky wall constructed by the wasp larva. In both ichnospecies the micromorphology of the casts is similar to the matrix where they are found. Indicative of subaerial exposition, *Fictovichnus gobiensis* is found in all four facies/environments, whereas *Fictovichnus isp*. nov. is restricted to the wet mudflat. They are controlled by: a) shallow groundwater that permit the installation of phreatophytic plants and the nesting of wasps in dry upper soil horizons, and b) the rise of groundwater table that favored decomposition of plants and cementation of both, the filling and the lining between the matrix and the chambers, enabling the preservation of the insect trace fossils.

Combined sedimentological and ichnological studies of continental basins can lead to a better understanding of the characteristics of sedimentary processes, as well as to the diagenetic processes and paleoecology of ancient terrestrial landscapes. Our study shows that very early diagenetic processes, controlled by the rise of groundwater, are key for the preservation of these insect traces. The lack of these processes may be responsible for the scarcity of insect trace fossils in other similar continental basins.

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Quantitative Analysis of Fluvial Sandbodies of the Toolachee Formation, Cooper Basin, Australia

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The Cooper basin produces oil and gas from numerous fluvial channel sandstone bodies deposited within several formations such as the Late Permian Toolachee formation; however, the geometry of these fluvial deposits are not well-constrained. Five sandstone bodies (SS1 to SS-5) have been identified within the Toolachee Formation. These sandstone bodies are characterized mainly by fining-upward packages which have been interpreted to be deposited by high-sinuous channels. This study aims to determine and interpret the size, geometry, and architecture of these fluvial sandstone bodies identified within the Toolachee Formation from well logs in Meranji field. The morphometric parameters examined in this study include channel width (*w*), channel depth (*d*), and meander belt width (*mbw*). All of these parameters have been determined using the empirical equations driven from modern river. The estimated maximum bankfull depth (*d*) ranges from 3.3 to 6 m and the estimated channel width (*w*) from ranges from 42 to 105 m which indicates that these sandstone bodies were deposited by relatively small fluvial channels. The estimated meander-belt width (*mbw*) from ranges from 800 to 2000 m which indicates that some of these sandstone bodies (e.g. SS-1, SS-4, and SS-5) are connected and can be correlated between the adjacent wells within the Meranji Field. This indicates that these sandstone bodies are excellent reservoirs due to good their lateral extent. The empirical equations described above have improved the quantitative estimations of the channel dimensions and connectedness of the sandstone bodies. These equations can help to reduce the number of wells that are planned to be drilled in Meranji Field.

Response of shallow-marine C-isotope record to environmental and diagenetic changes. Bearing on orbital cyclicity and chronostratigraphy of Barremian-Aptian times

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This study contributes to a better understanding of the Lower Barremian-Lower Aptian shallow-water carbonates, which were deposited during a period of enhanced climatic changes due to greenhouse conditions punctuated by cooling episodes. Detailed lithostratigraphic and cyclostratigraphic study was presented in Amodio et al. (2013). Here we discuss the C-isotope stratigraphy of shallow-marine carbonates from S. Maria cores drilled in the central Apennines and from M. Faito section that crops out in the southern Apennines. Analysis of C and O isotopes was performed on 737 bulk carbonate samples. No systematic variation of the $\delta^{13}C$ values within the lithofacies associations was recognised in both case studies. Moreover, low to moderate covariance of the $\delta^{13}C$ versus $\delta^{18}O$ bulk samples indicates the absence of strong meteoric diagenetic alteration of stable isotope signal.

For the purpose of isotope correlation a five-point moving average was calculated for all C-isotope values of the analysed sections. The $\delta^{13}C$ curves of the S. Maria and M. Faito appear to preserve potentially the global marine C-isotope signature registered during the Early Barremian-Early Aptian time interval. This is also confirmed by the regional C-isotope correlation with the reference section of M. Raggeto (M. Maggiore, southern Apennines, Di Lucia et al., 2012, Wissler et al., 2004).

Based on the precise location of the magnetozone M0r and the pelagic Selli Level Equivalent (SLE), a high-resolution C-isotope correlation of the three above mentioned carbonate sequences with other Tethyan sections of Cluses (Urgonian Platform, France, Huck et al., 2013) and Gorgo a Cerbara (Umbria-Marche Basin, Sprovieri et al., 2006) has been carried out. The Cluses and the Gorgo a Cerbara sections represent the stratigraphically most complete records in shallow and deep waters, respectively. Notwithstanding the shallow-marine sections show exposure events (and more extended gaps), with consequently fluctuating carbon-isotope values, the Barremian–Aptian $\delta^{13}C$ pelagic excursions appear well preserved here. On the other hand, the Gorgo a Cerbara section provided a detailed time calibration for the CM0-CM3 boundaries, recognized throughout the section as well as for the Barremian Stage.

Based on orbital chronostratigraphy, we have registered 13 superbundles (400ky orbital cycles) up to the base of CM0r and estimate a minimum duration for the Barremian of 5.2 my, which is similar to about 4.5 my estimated for the Barremian Stage in Sprovieri et al. (2006). By additional data from S1 core drilled at M. Raggeto, where CM3-CM5 boundary was identified, we consider the base of M. Raggeto section close to the base of the Barremian. On the other hand, in the Aptian segment our orbital cyclostratigraphy suggests that Chron M0r may span about 0.4 my; the SLE begins at about 0.4 my after the end of Chron M0r and lasts about 1.2 my. These results agree with the duration suggested by several authors and referred to in the Geological Time Scale 2012.

Early Miocene, flat-topped carbonate ramp: a wave-dominated, tide-modulated islands environment (Sardinia, Italy)

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At the onset of the Miocene the Corse-Sardinia Block was part of the southern European continental margin, it was located close to the present-day Gulf of Lione and represented the Arc-Back-Arc zone associated with the westward subduction of Adria Plate beneath south-Europe. In this geodynamic context the west side of Sardinia Island was segmented into several sub-basins and subsequently formed a 100 km long, NNW-SSE oriented seaway. This work discusses the Oligocene-Early Miocene temperate-type carbonates developed in the Isili sub-basin (SE Sardinia, Italy, Western Mediterranean). The carbonate system developed in a small strait environment between an island and the mainland, this morphology was related to the tilting of basement blocks that occurred during the extensional tectonics affecting the Arc zone. The depositional profile of the carbonates resembles a flat-topped ramp, which progradeed landward, filling a shallow-marine embayment. The micro- and macro-faunal constituents are consistent with a paleo-bathymetry of 5-30 m depth with several species (oysters, barnacles and lithophaga) indicative of an intertidal/shallow-subtidal setting. The system is characterized by two main depositional zones recording different levels of hydrodynamic energy: the flat zone and the onshore-directed ramp.

The flat zone is characterized by planar to trough cross-stratified and cross-laminated rudstone/grainstone bodies alternating with highly bioturbated (*Glossifungites*-like) floatstones/packstones. This is interpreted to represents a moderate energy environment with colonized by algal forests and scattered seagrass meadows, with strong fluctuations in the hydrodynamic regime.

The prevailing energies acting over the flat were unidirectional, onshore-directed currents that formed extensive rhodolith and bioclastic-rich banks. The formation of these banks is interpreted to have resulted from storm events, with a multiannual tidal cyclicity controlling onshore-directed migration.

The onshore ramp zone is characterized by a flood tidal delta-like system with decametre-long sigmoidal bodies. These were generated by the flow expansion of multiple current events promoting the formation and migration of several bedload structures along an inclined profile (clinoform). Multiple events generated clinoforms that built up lobe-shaped bodies arranged in a complex lateral and vertical stacking pattern.

The narrow constriction created by the emergent island most-likely controlled the water circulation amplifying wave, wind and tidal currents, however, bedforms are also present where the embayment is wider. Although wave mechanisms in micro-tidal settings could be invoked to explain some of the individual sedimentary structures, it is not realistic to apply this explanation for the complete sedimentary system of the study area. A wave-dominated, tidal-modulated origin within a meso- to macro-scale tidal regime provides the best explanation.

The ability of a basin to develop a large tidal range depends on the interaction between the amphidromic system and the basin configuration. Thus, the coexistence of a narrow, shallow-water seaway together with large tidal waves that could enter into the older western Mediterranean from the Atlantic sea through a wider Gibraltar Strait would have promoted tidal range amplifications along the study area during the onset of the Miocene.

Devonian lacustrine shore zone architecture: giving perspective to cliff exposures with ground penetrating radar

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Lake margin sedimentary systems have been the subject of only limited study. The orbitally controlled cyclic lacustrine successions of the Middle Old Red Sandstone of Northern Scotland contains repeated developments of shore zone sandstones and thus provides an ideal location for the study of these units. The cycles are on average 16 m thick and comprise deep lake, perennial lake and playa facies. The shore zone facies reaches 2 to 3.5 m in thickness and is found within the playa facies. Detailed field observations are presented alongside ground penetrating radar data which has aided the three dimensional characterisation of these sand bodies.

Loading and discrete channel forms are recognised in thin-bedded sandstones within the lower portion of the lake shore zone successions. Radar profiles provide evidence for an extensively developed sharp base to these units with some erosional features also recognised. Up-section the sandstone beds appear to become amalgamated forming subtle low angle accretionary bar complexes. These features are imaged well on the radar profiles where successive erosion/accretion can be recognised and their three dimensional form and distribution mapped. The orientation of these features is consistent with extensive palaeocurrent measurements from oscillation ripples. Further loaded sandstone beds and sand-filled shallow channel features overlie the bar forms. The channels are well imaged in the radar scans where their wider context can be gained.

The shore zone sandstones overlie playa facies which contains abundant desiccation horizons, reflecting the most arid phase in the climatically controlled lacustrine cycle. As climatic conditions ameliorated the rejuvenation of fluvial systems resulted in the transport of sand out into the basin. Initial deposition was limited to intermittent events where sediment was laid down on a water saturated substrate. Some of these may have occurred subaqueously as small scale turbidity flows. High resolution fluctuations in lake level resulted in periodic short lived reworking events along the lake margin which produced amalgamated sands which formed low relief bars. Shore zone reworking is likely to have occurred over a wide area as the lake margin migrated back and forth, and gradually transgressed. Continued transgression forced fluvial systems back towards the basin margin.

Detrital Zircon and Rutile Geochronology and Petrochronology of the Central Northern Alpine Foreland Basin, Switzerland

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The sedimentary deposits of the Eocene to Miocene central Northern Alpine Foreland Basin in Switzerland are well studied yet they lack thorough geochronologic and petrochronologic analysis of detrital zircon and rutile. The tightly constrained depositional ages of the strata provide an excellent opportunity to use U-Pb geochronology coupled with rare earth element and trace element data (petrochronology) on detrital zircon and detrital rutile to elucidate the tectonic activity of the central Alpine Orogen from the late Eocene to mid Miocene and to provide further insight on provenance of the strata. The well-constrained nature of the basin provides an exceptional setting to test the utility of detrital zircon and rutile petrochronology in provenance analysis.

The central Northern Alpine Foreland Basin in Switzerland is characterized by two upward coarsening mega-sequences divided into five lithostratigraphic units: North Helvetic Flysch (NHF), Lower Marine Molasse (UMM), Lower Freshwater Molasse (USM), Upper Marine Molasse (OMM), and Upper Freshwater Molasse (OSM). These strata record the exhumation of the central Alpine Orogen and have well documented bio- and magneto-stratigraphic constraints on depositional age. The samples analyzed are collected primarily from exposures within the sub-Alpine Molasse near Lake Lucerne, Switzerland. Samples were also collected from secondary sections near Lake Constance and Lake Thun.

Over 2500 detrital zircon U-Pb ages obtained from the Lake Lucerne section are dominated by recycled ages of the Cadomian, Caledonian and Variscan Orogens. During deposition of the NHF, UMM, and lower USM from 35-23 Ma, the detrital zircon U-Pb populations are dominated by age groups of 550-600 Ma (Cadomian), 450-480 Ma (Caledonian) and 300-320 Ma (Variscan). At around 23 Ma, within the USM, through deposition of the UMM, and to the youngest sample at approximately 13.5 Ma the detrital zircon U-Pb populations are dominated by 270-290 Ma (post-Variscan) ages, with a secondary abundance of 450-480 Ma (Caledonian) ages. The Cadomian, Caledonian, and Variscan ages from the 34 Ma to 23 Ma units are consistent with previous interpretations that initial deposition into the basin records the exhumation and erosion of Austroalpine cover units. The dominant post-Variscan age peak from units deposited between 23 Ma and 13.5 Ma records the exhumation of upper-Penninic units.

While analyzing for detrital zircon U-Pb ages on the LA-ICPMS, the sample gas from select samples was "split-streamed" to a second ICPMS to determine Rare Earth Element and trace element abundances simultaneously (Petrochronology). The REE and trace element data provide a link between age and genesis of the zircon. This same method of petrochronology was also applied to detrital rutile.

Similar to zircon, rutile is one of the most stable detrital minerals within a sedimentary system and individual grains contain an informative geochronologic and trace element signature. Rutile petrochronology was used to determine the contribution of mid- to high-grade metamorphic sources available to the sediment budget of the central Northern Alpine Foreland Basin during growth of the central Alps. The detrital rutile U-Pb ages also document a shift in provenance around 23 Ma.

The combined techniques of detrital zircon and rutile geochronology and petrochronology help to further constrain the exhumational and tectonic history of the central alpine orogen. In turn, the well-constrained depositional history of the basin allows us the opportunity to evaluate the effectiveness of the analytical techniques and provide insight on their use in other sedimentary basins.

Volcanogenic Sediment Identification as prolific hydrocarbon in Western part of South Sumatra basin

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Volcanogenic sediment or Volcanoclastic sedimentary rocks known as a differential product of volcanic eruption which redeposited with tranport mechanism such as fall dawn, flow and surge. The most volcanic activity are distributed in plate boundaries and form the volcanic rock distribution area such as Indonesia that well known as the ring of fire. South Sumatra Basin (SSB) where placed at plate boundaries also one of these volcanic rock including volcanogenic sediment distribution in Indonesia.

The Meruap field which Air Benakat formation as reservoir in this field where regionally known as a delta-shallow marine conventional sedimentary rock, thereafter drilled several development well, we found difficulties in geological correlation and modelling. Revisit geological study such as core interpretation, petrography analysis, X-RD analysis, X-RF analysis and petrophysic studies with their advance open hole wireline logging interpretation were conducted in this field. Result of these analysis were showing volcanogenic sediments like volcanic sandstone, tuff and volcanic breccia (lapilli tuff) as a reservoir. Bunga Mas field where situated in southern of Meruap field that recently drilled some exploration well, conducted same analysis where the result also showing volcanogenic sediments as reservoir rocks, there are not only in Air Benakat formation but also in the older formation like Gumai Formation and Talang Akar formation.

According into the data of these two field, we identified volcanogenic sediment as reservoir distributed in the western part of SSB, it means the western part have different sedimentary system with the eastern part of SSB. These differences would change previous regional geology understanding in SSB.

Keywords: Volcanogenic sediment, SSB, Sedimentary system

Sedimentological, geochemical and petrophysical characteristics of fault front travertine, Western Anatolia, Turkey

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Quaternary travertine and tufa bodies, attached to a normal fault plane that bound the Denizli Extensional Basin (Turkey) from the southeast have been investigated from a sedimentological, geochemical and petrophysical point of view. The travertine bodies that occur in different elevations precipitated mainly in two depositional settings, i.e. Slope (1) and Waterfall (2).

North-facing slope deposits at the lower elevation, consist mainly of smooth- and terraced-slope facies, of which the most dominant lithotype consists of crystalline calcite layers associated with dark micrite, erosion surfaces and palaeosol horizons including lithoclasts. Terrace pools were filled by dark and light coloured travertine layers, palaeosols and lithoclasts. Locally, bedding surfaces and cavity walls as well as reed molds were lined by secondary calcite. Slope travertines pass laterally and vertically into the pool facies dominated by dark and light micrite. Horizontal to subhorizontal bedded travertines of the pool facies occasionally overlap with slope facies. In some cases, leveling up from the terraced slope to smooth slope facies or steepening up from smooth slope to the terraced slope are evident.

In contrast, the coalesced waterfall tufa bodies occurring at higher altitude (from 595 to 650 m) are attached directly on the normal fault plane delimiting the Mesozoic limestone. The waterfall bodies consist of inclined, porous layers with angles up to 45°, hanged curtains and flowstones. Occasionally, the inclined layers are accompanied by coarse detrital materials derived from limestone bedrock.

The most abundant trace elements are Sr (256 to 2035 ppm), Mg (148 to 6624 ppm) and S (most values between 2000 and 5000 ppm), while Ba is low (up to 33 ppm). Stable Carbon and Oxygen ($\delta^{13}C$ and $\delta^{18}O$) values of the travertine-tufa samples range between +2.7 to +6.2‰ (V-PDB) and -8.7 to -7.5 ‰ (V-PDB), respectively. Crystalline calcite samples from terrace pool rimstones and smooth slope facies display a more uniform distribution of the $\delta^{13}C$ (+4.9 to +6.1‰).

Helium porosimetry, air permeability and mercury injection capillary pressure (MICP) tests allowed to petrophysically characterise the travertine samples. Qualitatively, the reed-biomoldic, fenestral and separate or touching vuggy pore types constitute the most prominent pore spaces both on micro and macro scales. According to MICP tests, the most common pore size is determined as meso-pores, ranging between 0.5 and 6 µm, especially in the crystalline crust and dark-coloured micrite lithotypes. Generally porosity values in the travertine samples studied are high (37.8 to 8.3%), while the corrected permeability values are relatively low (16.56 to 0.05 mD). This likely relates to the patchy distribution of the pores. Although some of the crystalline crust and dark-coloured micrite lithotypes possess high porosity values with pores uniformly distributed, permeability values of them is low. While this indicates that the eukaryote and bacterial microorganisms increase the porosity by leaving numerous isolated spherical, blocky and tubular micron and meso-sized holes with uniform outline as observed in the scanning electron microscope, carbonate mud produced by these microorganisms also causes the occlusion of pore spaces. In addition, cementation that caused by pore-fluid of high Mg/Ca leads to gradual reduction in pore connectivity. In conclusion, the studied travertine deposits apparently display low reservoir characteristics.

Sediment monitoring around submarine outfalls at continental shelf adjacent to Guamare Oil Pole, NE Brazil

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The Guamaré Oil Pole is located in the Northern Rio Grande do Norte State, in the extreme NE of Brazil. Geologically it is inserted in the Potiguar Basin. Its adjacent shelf presents mixed siliciclastic-carbonate composition, and seabed features ranging from incised valleys to submerged dunes. Literature studies indicate the division of this shelf in three different environments: the inner shelf (mainly siliciclastic sediments, with longitudinal dunes formation), middle shelf (mixed sediments, forming transverse dunes) and outer shelf (bioclastic sediments, steeper morphology). Its features of geomorphology, sedimentology and structural are strongly correlated with the adjacent coastal environments, such as the dynamic and sedimentation correlation are very important. Great influence of hydrodynamic agents like W-E longshore drift, SE and N winds and semidiurnal tides cause mobilization in large scale of sediments that further erosional processes. As the oil and gas industry in this region has been installed since the 80s, with exploration, exploitation and transport activity, is very important execute the environmental monitoring in order to prevent and minimize possible accidents. The water used in all marine and terrestrial fields, after passing through the wastewater treatment process, is discharged at sea through two outfalls, with total load about 80,000 m³ per day. The objective of this work was the seabed sediment characterization surrounding these outfalls, in two different times (October 2009 – June 2011), in order to observe if sedimentological changes occur in the area. Sediment samples were collected from the first 10 cm, with a dredger-type van-veen. The sampling grid defined around the outfalls was composed by concentric circles in the main discharge area (50m, 200m, 500m, and 1000m radius). One control area with a 20 kilometers distance to the East was also defined. Samples were first processed in laboratory for salt washing, carbonate content and grain size analyses Using a binocular reflected light microscope, the qualitative sediments characterization was taken in relation to their mineralogical composition, percentage of siliciclastic (quartz, high density minerals and rock fragments) and textural aspects (sphericity and roundness). The results indicate that most of the samples present medium roundness varying from sub-angular to sub-rounded in both cruises. As well as an increase in the siliciclastic grains contents from one cruise to the other, and also an increase in the percentage of rock fragments and high density minerals. This increase could be associated to seasonal changes, since October is a dry period, while June is a rainy one; or even due to the human factors, in this case related to the outfall fixing. However, more studies, such as provenance and geomorphologic studies, must be performed to better explain these results.

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Keywords: seabed composition, oil exploration, Potiguar Basin.

Isotopic composition of the water of crystallization of gypsum as a tool for genetic interpretation: Application to the Vilobí Gypsum Unit (Miocene, Barcelona)

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The isotopic composition of the water of crystallization of hydrous minerals has numerous applications in studies of recent climate change and ore deposits. However, the isotopic analysis of oxygen and hydrogen has been a complex procedure until the first on-line methodologies appeared. These techniques are based on a continuous-flow isotope ratio mass spectrometer equipped with a thermal reduction furnace and a chromatographic column. We present an improvement of the methodology previously reported for the extraction and isotopic determination of the water of crystallization of hydrous sulphates, and its application to the Vilobí Gypsum Unit (Barcelona) in order to decipher its origin and diagenetic evolution.

The major improvements achieved are related to the height within the furnace where the dehydration of the sample occurs. Thus, a height of 135 mm was set below the top of the ceramic tube and at that point the reactor acquired a temperature of 600º C which is the appropriate to release the water of crystallization of most hydrated sulphates.

The methodology developed in this work was applied to the Vilobí Gypsum Unit (Miocene, Barcelona). This evaporite unit shows an interesting range of gypsum types (primary and secondary gypsum) and textural varieties (alabastrine, radial aggregates and lenticular megacrystals), as well as gypsum cements related to different fracture sets. The sulphur and oxygen isotopic compositions suggest a marine origin for the sulphate of the primary and secondary gypsum subunits. However, the isotopic composition of the water of crystallization of the primary gypsum has allowed us to reinterpret the origin of this subunit: isotope values suggest that it was formed from non-marine water, possibly in a *lacustrine* environment, and not from marine water as previously reported. This data is in agreement with a closure of the basin and an interruption of the marine water contribution. Isotopic values of the water of crystallization of the secondary gypsum indicate a meteoric origin, as expected. Isotopic differences between the textural varieties of the secondary gypsum could not be established. Finally, the isotopic composition obtained for the gypsum cements suggests precipitation from meteoric waters saturated in calcium sulphate.

As a result of the improvements developed in this study, the on-line, continuous-flow methodologies for the extraction and isotopic analysis of the water of crystallization of hydrous sulphates are suitable for this purpose, as well as quick and inexpensive.

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Effect of igneous dykes on geochemical properties of shallow marine-originated black shales: Kimmeridgian Jhuran Formation, India

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This study focuses on organic geochemical characterization of carbonaceous shales in the Kimmeridgian Jhuran Formation in Kutch mainland basin within western India and highlights the effects of igneous dykes on geochemical properties of shales. Unconformably resting over Dhosa Oolite carbonate succession, the three-tiered Jhuran Formation exhibits extensive organic-rich shale in the lower and middle segments, which are intervened by siltstone and sandstone interbeds of variable thicknesses at different levels. The lower and middle segments of the formation together indicate deepening upward trend while the upper segment exhibits shallowing upward trend, and is unconformably overlain by Early to Late Cretaceous Bhuj Formation. Shallow marine origin of the carbonaceous shale has been inferred by frequent presence of plant leaves and twigs, abundant wave ripples on interbedded sandstones, occurrences of hummocky cross-stratified sandstones, polymodal palaeocurrent direction of tool marks at the base of sandstones and occurrences of trace fossils *Gyrochorte*, *Arenicolites*, *Skolithos*, *Planolites*. Total organic carbon (TOC) content and Tmax of these shales range from 1.7% to 2.8% and 427°C to 431°C, respectively. The values suggest immature nature of the organic matter. HI and OI values range from 46 to 158 mg/g and 19 to 71 mg/g, respectively suggesting dominance of type-III kerogen in shales. Low S1 values (av. 0.04 mg/g) suggest absence of free hydrocarbons. Biomarker study reveals abundance of coniferal compounds namely ent-beyerane, phyllocladane, ent-kaurane, retene and simonellite. Igneous dykes intrude the shales at several localities, altering organic geochemical characteristics of these shales. Present study focuses on the alteration of geochemical properties of shale against a mafic igneous dyke of about 17 m thickness in a 21 m thick outcrop. The dyke causes an intensely burnt zone of alteration around its periphery up to 2.0 m, and weakly burnt zone up to 17 m distance. Average TOC and Tmax values of the samples at the intensely burnt zone are 2.5% and 595°C respectively. Sharp drop in Tmax is recorded from 589°C in the intensely burnt zone to 458°C in the weakly burnt zone. Thereafter, Tmax values decreases gradually within the weakly burnt zone from 458°C to 432°C for the systematically collected shales samples (1 m spacing) from the same bed. Average HI and OI values of the intensely burnt zone are 10 and 20, respectively suggesting complete burning of organic matter. Weakly burnt zone to unburnt shales exhibit more or less gradual increase in HI values from 39 to 84 and OI from 36 to 80. Although most major and trace elemental concentrations of bulk samples are minimally affected by igneous dyke Sc, Y, Zn, V, Mn, Sr show a marked depletion, Zr, Co, Cu, Cr show preferential enrichment within intensely burnt zone and Ba, Ti, P concentrations remains unaltered. The organic geochemical data of outcrop samples reflects sharp change of Tmax in the intensely burnt zone and systematic changes in HI, OI and Tmax in the weakly burnt zone and minor alteration of bulk elemental concentrations of shales.

Using foraminifera to characterize the depositional environments of deep-marine basins

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Deep marine sedimentary systems are important locations for the formation of hydrocarbon reservoirs and accumulation of hydrocarbon deposits. While large-scale basin analysis can be resolved seismically, the identification of the different depositional environments within these systems is reliant on detailed sedimentological studies to unravel the fine-scale complexity of these systems. To help constrain the sub-environments of deep-marine basin systems, outcrop analogues can be studied and used as a basis for interpretation of paleoenvironment and the depositional setting. In this study we aim to provide a foraminiferal classification scheme for deep marine environments that incorporates the diversity of depositional setting that are recognized in outcrop analogues, and which can later be applied to subsurface deposits.

To aid in the identification of these systems, outcrop analogues in France (Grès d'Annot) and Italy (Marnoso-Arenacea) and Mexico (Rosario Formation) will be studied. A classification scheme using microfossils will be developed for the purpose of improving knowledge of the deep-marine systems and providing a classification system to be used in the context of subsurface deposits. The Grès d'Annot system represents confined to ponded submarine fans; the Marnoso-Arenacea system represents a variably confined submarine fan to basin plain deposit; the Rosario Fornation represents a slope system including channels and levees. These systems have been chosen as outcrop analogues of subsurface systems because of the comparability in age and depositional setting with some offshore Brazil deep-marine sedimentary basin deposits.

Foraminifera are useful in biostratigraphic and environmental indicators of their depositional environments and are ubiquitous in global oceans throughout the geological history. A classification scheme for the deep marine systems will be established using planktic and benthic foraminifer species abundance and benthic morphogroups characteristic of each sub-environment. Benthic morphogroups are particularly informative because of the relationship between foraminifera test morphology and environment. The association of key species and morphogroups with different water depths, environments, sedimentary substrate will enable the definition of fine-scale depositional features within context of the broader deep-sea basin system. Reworking or mass transport can also be recognized in the qualitative assessment of foraminiferal preservation and depth habitat analysis.

Preliminary results presented here will provide an outline of the foraminifer classification scheme based on a pilot study of the outcrop systems. Preliminary foraminifer species and benthic morphogroup analysis will provide an initial paleoenvironmental interpretation of the various sub-environments within the two systems. This will provide the basis for further detailed study and the creation of a detailed classification scheme for application to subsurface samples, improving interpretation of depth and depositional environment of subsurface deep marine sedimentary deposits.

Sedimentary evolution of a microbial-siliceous sponge dominated carbonate platform (Bajocian, Iberian Basin, Spain)

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Facies analysis of the Bajocian outcrops exposed near Moscardón (Iberian Basin, NE Spain) has resulted in the reconstruction of the facies architecture in a key area of the carbonate platform, characterised by the widespread occurrence of microbial crusts. The obtained data provides further understanding of the sedimentary processes, facies and building blocks found in the transition area between the shallow and relatively deep carbonate platform domains, located above and below wave base level respectively.

Widespread development of microbial crusts took place in the slop segment of the carbonate platform located below wave base level. On the upper slope, in a depth range around 30–50 m, microbial crusts and siliceous sponges formed up to 3–6 m-thick lens-shaped biostromes, which were piled up to form larger-scale mounds. The overall geometry of these mounds was controlled by the evolution of the accommodation. During stages of rapid accommodation gain, vertical aggradation of the biostromes resulted in the formation of up to 25 m-thick mounds, with flanks dipping up to 25º in a down-slope direction. During stages of sea level highstand the building blocks were dominated by lateral accretion, resulting in lens-shaped geometries up to 10–20 m thick.
The transition between the upper slope and the shallow platform area was dominated by microbial-encrusted intraclastic-bioclastic packstones. Episodic microbial crust development above wave base helped to stabilize the sand-size seafloor sediments, allowing the eventual in-situ accumulation of grain-supported facies. This episodic formation of flat, stable substrates explains the overall geometry of the shallow platform facies, which form a pile of plane-parallel and continuous beds that were able to build above wave base level.

The interaction of relative sea-level changes (i.e., two transgressive-regressive Baj-1 and Baj-2 sequences recognized at basin-scale) and internal factors (i.e., microbial growth and wave base level location) was the major control on the geometry and overall facies architecture of the carbonate platform. The stacking pattern of the Baj-1 sequence, mostly developed below wave base in the study area, consists of an aggradational transgressive hemicycle, followed by a stage of accommodation fill with local offlap geometries during the regressive hemicycle. In contrast, during the early regressive hemicycle of the Baj-2 sequence, the stage of large carbonate production over the upper slope areas, combined with wave erosion during the stable sea level, resulted in the erosional truncation of the upper slope progradational clinobeds. During the late regressive hemicycle of the Baj-2 sequence, the shallow grain-supported facies deposited above wave base were able to build up an aggradational (and shallowing upward) stacking pattern with plane-parallel geometries.

Holocene sedimentation and palaeoecology of the Herodotus historical coastal lake of Keri, Zakynthos Island, Greece

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In the present study we interpret the depositional palaeoenvironment of the coastal Keri Lake, which is located on Zakynthos Island, western Greece. The first information about the Keri Lake came 2500 years ago from Herodotus, the famous ancient Greek historian of the fifth century BC, thus the lake was named after him. However, it is also well known because of asphalt-hydrocarbon seepage. In order to interpret the Holocene evolution of the area, samples from vibracores to a depth of seven meters were analyzed for their total organic carbon, total nitrogen and sulfur contents, as well as for their micro- and macro-fauna. The chronological framework of our study was based on three ^{14}C dates, while the age depth model and the sedimentation rate were calculated applying OxCal software. The age depth model infers an age around 6000 yrs BP, while the rate of sedimentation shows a mean of 1 mm/yr. The micro and macrofossil assemblages indicate two different sedimentological units. The lower one (7.00-3.80 m deep beneath surface) is strongly influenced by the sea, since it contains mainly planktonic (up to 90%) and shallow shelf benthic foraminifera. The upper one (3.80 m deep up to the surface) is indicative of fresh water deposits as it contains mainly fresh water low salinity ostracods, fresh water gastropods and charophyte gyrogonites; in addition two anoxic/hypoxic events are observed. The trends of the geochemical parameters TOC, TN and TS reflect the different sedimentological units. The obtained results show that during the middle Holocene the Herodotus Lake was influenced by a sudden sea water inundation event, possibly as result of tsunami or storm events, while in the late Holocene it used acting as a brackish coastal fen, where peat was accumulating, under the significant inflow of fresh water originated from the karstic systems of the catchment area.