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Abstracts Oral Presentations

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Coupling Timing and Tempo of Deccan Volcanism with the KPg Extinction through Mercury and Tellurium Anomalies

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Mercury (Hg) and more recently tellurium (Te) are indicator of large-scale volcanism in sediments and provide valuable insights into relative timing between biological and environmental changes, mass extinctions and delayed recovery. Several studies evaluated the relationship between Hg anomalies in sediments and LIP activity across mass extinction horizons. The bulk (80%) of Deccan Trap eruptions occurred over a relatively short time interval in magnetic polarity C29r. U-Pb zircon geochronology reveals the onset of this main eruption phase 350 ky before the Cretaceous-Tertiary (KT) mass extinction. Maximum eruption rates occurred before and after the K-Pg extinction, with one such pulse initiating tens of thousands of years prior to both the bolide impact and extinction, suggesting a cause-and-effect relationship. We analysed Deccan Traps Hg-Te loadings, on 30 KPB sections deposited in both shallow and deep environments. In all sections, our findings indicate that Hg and Te concentrations are more than 2 orders of magnitude greater during the final 100ky of the Maastrichtian up to the early Danian P1a zone (first 380 Ky of the Paleocene). Notably, Hg anomalies generally show no correlation with clay or total organic carbon contents, suggesting that the mercury enrichments resulted from higher input of atmospheric Hg species into the marine realm, rather than being driven by organic matter scavenging and/or increased run-off. Significant and coeval Hg and Te enrichments are observed in multiples basins characterized by proximal and distal, as well as shallow and deep-water settings, supporting a direct fallout from volcanic aerosols. Hg and Te maximum loadings coincide with time of maximum Deccan emission rates and volumes determined by zircon dating. These observations provide further support that Deccan volcanism played a key role in increasing atmospheric CO_2 and SO_2 levels that resulted in global warming and acidified oceans, increasing biotic stress leading the KPg mass extinction.

Seismic Interpretation of Upper Mississippian carbonate and clastic systems of the Solway Basin, East Irish Sea, UKCS

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The Solway Basin, located in the northern part of the East Irish Sea between the Peel and Lagman Basins, was formed due to transtensional tectonics, with the basin defined by NE-SW trending strike-slip faults. The aim of the study is to map the shape of the carbonate platforms and understand how clastic and carbonate systems interact within the basin. We used 2D and 3D seismic lines along with well data to study and determine the shape, size and thickness of the carbonate platforms within the basin. A major challenge was the lack of direct well control in this area, which meant that well-to-seismic correlation from the Peel Basin, located 10 km west of the Solway Basin, was required. We focused on two key layers: Top Visean, and Base Tournaisian.

Initial results show the distribution of small carbonate platforms in the upper Mississippian, forming isolated platforms along the western flanks of the basin. These platforms are uneven and fragmented, stretching from present-day shallow waters to the deeper parts of the Solway Firth. Their sizes range from 1 to 3 km, with steep slopes, often greater than 30 degrees and sometimes as steep as 60 degrees, likely due to faulting. The influx of siliciclastic sands from the northeast and north of the Solway Basin appears to impede the development of carbonate platforms, potentially leading to observed thinning of the platforms The eastern regions are dominated by clastic sands, and the centre of the basin shows layers of mixed clastics and carbonates, although it is difficult to distinguish carbonates due to the limits of seismic resolution (approx. 80m vertical resolution). By understanding the shape and structure of these carbonate platforms, we can improve our palaeogeographical models and better determine the controls on carbonate platform demise.

Integrated Sequence Stratigraphy of the Early Jurassic Datta Formation in the Potwar Basin, Pakistan

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The integrated sequence stratigraphy of the Jurassic clastic-carbonate mixed strata of the Datta Formation in the Upper Indus Basin of north Pakistan is presented here. The Datta Formation has been divided into two palynomorph biozones, namely the Callialasporites turbatus assemblage biozone (CTUABZ I) of Hettangian-Toarcian-Bajocian age in the upper part, while the Callialasporites trilobatus assemblage biozone (CTLUABZ II) of Bajocian-Bathonian age was demarcated in the lower stratigraphic section. Based on the palynomorph assemblage, amorphous organic matter, and phytoclasts, three types of palynofacies are identified, representing marginal dysoxic to anoxic basinal setting, heterolithic proximal shelf setting, and suboxic-anoxic shelf setting. The integration of palynostratigraphic information, palynofacies criteria, and outcrop data helped in the establishment of sequence stratigraphy. The Datta Formation represents two 2nd order and four 3rd order cycles encompassing two sequences (Sq1 & Sq2) which were deposited by the Highstand and and Transgressive Systems Tract. The relative sea level curve deduced from the facies information was used to compare the local sequences with the global sea level chart, which indicates three 2nd order and twenty-one 3rd order cycles. The sequence boundary within the Datta Formation is represented by laterite beds. The results showed that tectonics and climate both have affected the depsotional framework of the Datta Formation.

Sedimentology of a heterolithic tidally-influenced deltaic succession and implications for chlorite coating –Tilje Formation, Halten and Dønna Terraces, Offshore Mid-Norway.

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Chlorite coating occurring in subsurface sandstone reservoirs can contribute to preserving reservoir properties at great burial depth by inhibiting quartz overgrowths. Additionally, chlorite coats have high mineralisation potential for permanent CO2 sequestration. However, the controls on the occurrence, distribution, and geometry of chlorite-coated intervals in subsurface sandstones are poorly understood. Modern analogues studies show that chlorite-coats originate from precursor clay minerals and that the distribution patterns of these precursor minerals are linked to depositional and biological processes. This shows the importance of characterizing depositional environments to understand the distribution of chlorite coats in ancient subsurface sandstones.

The Lower Jurassic Tilje Formation is a tidally influenced deltaic succession from which chlorite coating facilitating viable reservoirs down to 6 km has been reported for over thirty years. However, the succession is highly heterogeneous, and chlorite-coated intervals occur in complex patterns across the study area. Thus, detailed sedimentological analysis is required to understand depositional environments and their implication for the distribution of chlorite-coated intervals. This study aims to investigate the sedimentology of the Tilje Formation using a set of wells and cores from the Halten and Dønna Terraces, offshore Mid-Norway. Sedimentary facies and depositional sub-environments are correlated across the study area and linked with the occurrence and distribution of chlorite-coated intervals. This will be a significant step towards improving the understanding of controls on chlorite coatings in subsurface reservoirs, and will facilitate future integration with provenance data to deconvolve the petrographic and sedimentological controls on this important process.

Paleocene-Eocene Thermal Maximum and Its Impact on shallow marine benthic communities: A Multi proxies approach.

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The Paleocene-Eocene Thermal Maximum (PETM) was an exceptional burst of intense global warming occurred during the early Cenozoic. This hyperthermal episode has been related to a significant increase in CO2 levels in both the atmosphere and hydrosphere. This event is mainly recorded within the geological record as negative Carbon Isotope Excursion occurring in both terrestrial and marine ecosystems. In this study, we investigate two Paleocene-Eocene shallow marine successions in the Neotethys realm from the Salt Range and Surghar Range (Indus Basin; Pakistan). Here we present multidisciplinary data, including large benthic foraminifera assemblages, calcareous nanofossil assemblages, stable C-isotopes (organic matter), total organic carbon (TOC), mercury, bulk rock and clay mineralogy. This multi-proxy approach, applied to a continuous section, allowed us to detail the environmental changes that took place during the PETM and better understand the overall dynamic of the event. Preliminary data suggest a relatively limited impact of the onset of the PETM on large benthic foraminiferal assemblages, with the turnover from typically Late Palaeocene taxa to typically Early Eocene taxa mostly occurring during the recovery phase of the excursion. Geochemical and mineralogical data (in particular kaolinte abundance) suggest changes in the hydrological cycle, possibly connected to a more humid climate in the study area during the PETM. The consistency among the different datasets highlights the potential for studying these large and rapid carbon excursions using a multiproxy approach.

Controls of distributive fluvial system on hydrocarbon reservoir performance: Upper Bima formation, Northern Benue Trough, Nigeria.

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Fluid flow within fluvial reservoirs are often impacted by a lot of primary depositional processes, making them more difficult reservoirs in development stage. Understanding the depositional properties and facies can greatly improve reservoir recovery efficiency. Computer reservoir modelling and simulation packages have proven to be very useful for reservoir management and have provided the means of better characterization of the reservoirs.

This study is aimed at understanding the oil recovery and the performance of the different depositional facies of the Upper Bima Formation; in the proximal, medial, and distal zones, using a workflow that integrate sub-regional quantitative outcrop data.

Basin-wide analysis of the Bima was carried out using a combination of traditional field measurements methods, unmanned aerial vehicle and structure-from-motion techniques. Quantitative data from the outcrop study were used to build two reservoir models with the same petrophysical properties, fluid models, reservoir dimensions, pay thickness and well development strategy. The two reservoir models represent the proximal and medial/distal zones of the Upper Bima Formation. Both reservoirs were simulated using water flood depletion strategy for 15 years to determine the pattern of fluid flow and recovery efficiencies.

The results of the fluid flow simulation show a better reservoir performance and recovery in the proximal reservoir compared to the medial/distal. This reflects the increased in the depositional heterogeneity from the proximal to distal as observed in the architectural analysis of the reservoir using outcrop data. The onset of water breakthrough was only 3 years from the start of production in the medial to distal reservoirs, whereas proximal Bima reached water breakthrough 5.8 years after the start of production. Recovery efficiency in the medial reservoir is 43% and 47% in the proximal reservoir. This work demonstrates a workflow that integrate outcrop data for better understanding of subsurface fluid flow.

Compositional controls on the Lower Cretaceous Rodby Shale pore structure and surface area: a planned CCS top seal for the Acorn storage site.

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Heterogenous top seals are challenging to characterise due to their complex systems. For that reason, novel methods are carried out to investigate the complex pore system of the Lower Cretaceous Rodby Shale and the effect of compositional controls such as mineralogy on surface area. Representative core samples were selected for core logging, and mineral quantification from XRD analysis. Thin sections were made for optical and BSE-SEM imagining to investigate pore morphology and development. Grain size distribution is measured through LPSA analysis. Porosity and pore throat distribution is measured via MICP, and pore size distribution is measured through N2 adsorption analysis. Fractal dimension analysis is applied to investigate the degree of pore structure heterogeneity. The results show that the Rodby Shale is smectite-rich and cemented by calcite. From logging the cores and BSE images, the depositional environment of the Rodby Shale is marine, the calcite is mostly sourced from microfossils. The pores developed during diagenesis include interparticle, intraparticle pores, and pores associated with organic matter. The grain size ranges from very fine to medium silt which is reflected in the content of silt grade material in the Rodby Shale. From N2 adsorption analysis, the pores in the Rodby Shale are dominated by mesopores over micropores. The average pore diameter is 8.72 nm. There is a negative correlation between clay content and surface which is reflected by the presence of calcite cement. The influence of quartz content is leading to positive relationship between quartz content and surface area. The fractal dimension D1 is showing irregular pore surfaces of the Rodby Shale, and D2 show intermediate heterogeneity of pore structure.

A tale of arid climate and hydrothermal control on sedimentation in alkaline saline lakes: The Ibar intermontaneous basin natural laboratory in Serbia

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The Middle Miocene Climatic Optimum (MCO) is the global warming phase affecting the Earth's surface between ~ 17 and ~15 Ma. However, previous studies suggested that mountain-building processes even in the case of rather small orogens such as the Dinarides (SE Europe) may lead to variations in the regional climatic conditions. In this work, we test the hypothesis that the Dinarides were high enough to induce arid climatic conditions in the internal part of the orogen during the Miocene times. We investigate the evolution of the intramountain Ibar Basin (internal Dinarides, Serbia) by analyzing saline-alkaline lake succession using detailed sedimentological analysis, U-Pb dating of travertine acquired by LA-ICP-MS, and fluid inclusion analysis.
The eight facies associations are identified, middle to distal alluvial fan, flood plain, marginal lake sandstones and mudstones, microbiolites, delta front, prodelta, littoral to sublittoral oil shales, profundal siliciclastic turbidites. The stratigraphic distribution of the facies associations implies a transition to the lake environment following the alluvial phase at the onset of basin evolution. The U-Pb age of ~17 Ma in the travertines implies the onset of the lacustrine phase at the beginning of the MCO. Preliminary results of the fluid inclusion studies on travertines show two phases of calcite. The first phase calcite is coarse-grained, anhedral and contains cyclic precipitates of Fe-Hydroxides with high porosity. Second-phase calcite fills interstitial vugs and quartz-rich fractures cut the whole sequence. Colemanite overgrown by ulexite forms a discrete boron mineralization in the pores. The primary fluid inclusions in colemanite and calcites indicate a beginning of precipitation at ~3 wt.% salinity and temperatures of ~80-100°C implying a hydrothermal effect. The brine shows a continuous evolution from low- to high-salinities (31.1 wt%NaCl+$CaCl_2$) with decreasing Cl/Br ratios reflecting an evaporating bittern brine at the surface whose saturation was reached in an arid climate.

The s-shape in sedimentology: what controls of shape and slope of clinoforms?

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Clinoforms are sloping depositional profiles, characterized by a gentle topset, sloping foreset and gentle bottomset. They are fundamental building blocks in sedimentary geology, the quintessential s-shape is observed from cm-high ripples to kilometer-scale continental margins. They owe their genesis, morphology and size to a complex interplay of factors. The shape develops with systematic decay of competence and/or sediment from a site of deposition, generating differential loading of a typically lense-shaped sedimentary body.

All forms are to some extent governed by accommodation and energy limiting factors (water agitation and/or flow regime). Smaller clinoforms can, owing to less sediment required for progradation, merge with larger forms. Lithology exerts an important control, as the systems can build to angle of repose, which is higher for coarser non-cohesive sediment, while cohesive sediment also fails at lower angles induced by excess pore-pressure. Additionally lithology influences curvature, as heterogeneity creates greater contrast between slope segments.

Lithology and sediment rate appear to exert more fundamental control on steepness, compared to depth. Typically steeper slopes are observed with increasing depth, but there is much disparity, and the slope might rather reflect comparatively limited sediment rate.

There are four primary clinoform shapes: concave, linear, convex, sigmoidal, developing in response to variations in sedimentation resulting from erosion/bypass/limited deposition/accumulation/sediment supply. Sigmoidal clinothems, associated with high A:S ratios, are typically shorter and steeper than concave clinothems. Decaying shear-zone agitation and/or reworking and erosion shapes the rollover. Decaying sediment amount and carrying capacity shapes the ensuing curvature. Concave slopes, with sharp rollovers and lacking topsets sharp rollovers are often longer with lower angle than sigmoidal forms. Their formation is likely closely linked to increased lower slope accumulation through slope failure, bypass, and/or turbidity currents, but can also be from increased suspension-dominated deposition in smaller clinoforms.

Inter-relation of tectonic uplift, glacio-eustatic sea-level change and climatic change: integrated case history of the Pleistocene fluvial sediments of the Tremithos River and related shallow-marine coastal deposits in SE Cyprus

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We investigate the relative controls of surface uplift, climatic change, and glacio-eustatic sea-level change on non-marine and shallow-marine sediments, as a single linked depositional system. For this, it is essential to integrate sedimentology with geomorphology, geochronology, and local- to regional-scale tectonics. Here, we present the Pleistocene sedimentary development of the Tremithos river catchment and associated coastal deposits in SE Cyprus. The overall driver was domal tectonic uplift of southern Cyprus, focused on the ophiolitic Troodos Massif. The later Pleistocene sediments that dominate the catchment accumulated under dominant influences of glacio-eustatic and related climatic change. The Early-Mid Pleistocene of the river catchment is mainly preserved as remnant erosion surfaces and rounded hills. The later Pleistocene was characterised by pulsed incision that deepened and narrowed the channel in its upper and middle reaches. A broader and shallower channel developed in the lower reaches, passing into a coastal alluvial fan. Incision events correspond to dominantly high-energy, flashy stream-flow in a cool, wet climate, generally correlated with interglacial periods. Channel fill was mainly achieved by lower energy, more persistent stream flow, associated with semi-braided and overbank deposition. Interbedded and marginal chalky colluvial deposits resulted from slope-wasting, during cool and humid periods. Overlying palaeosols, especially reddish-coloured terra rossa (pre-Holocene), record relatively warm and humid periods. Bedrock lithologies exerted a very strong influence on clast lithology and shape. High degrees of rounding relative to short-distance fluvial transport (< 25 km) point to recycling from older to younger deposits. Younger, more deeply incised fluvial deposits interfinger with uplifted Holocene shallow-marine terrigenous sediments and littoral carbonates (including solitary corals) in coastal areas. Some previously reported shallow-marine calcarenites are re-interpreted as aeolianites, characterised by well-developed rhizocretions and vadose cements. The Holocene coastal sediments were strongly affected by strike-slip (transpression) related to oblique convergence of the African and Eurasian plates.

High-resolution 3D outcrop model-based characterization of shoreface sequence architectures on an uplifting interbasinal relay zone: the Late Quaternary Corinth Isthmus, Greece.

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A central horst block preserves stratigraphy back to ~800 ka since when the Isthmus has been a tidal strait during periods of relatively high sea-level. The Gulf of Corinth basin has undergone episodes of marine connection during global highstands but experienced isolated lacustrine conditions when disconnected across the Isthmus during global marine lowstands (e.g. Gawthorpe et al., 2022). In the Canal, NW-dipping faults towards the Gulf of Corinth and SE-dipping normal faults towards the Saronic Gulf control the position of the central horst block high and exhibit variably planer to listric and both horizontally- and vertically- segmented geometries. Syn-depositional movement on these locally affected relative sea-level on a small scale, influencing the facies trends and their thicknesses.
The north-western Corinth Canal reveals the upper parts of 8 prominent transgressive-regressive cycles in the Quaternary coastal facies belt, which are bounded by surfaces recording both sub-aerial exposure and wave ravinement. Intervening shallow marine transgressive to highstand deposits are ascribed to the interglacial episodes of marine isotopic stages (MIS) 1, 5, 7a/c, 7e, 9, 11, 13 and 17 based upon our age model. Waves and tides effect the sediment geometries and have formed wave and/or tidal ravinement surfaces on sequence boundaries. Successive sequences offlap basinwards, suggesting an overall forced regression across the period of deposition. Individual transgressive surfaces, such as that correlated to the MIS 10-9 deglacial transition (a period of ~10kyr), include a) incised channels with fluvial infill, b) laterally extensive wave-cut platforms, and c) palaeocliffs that mark episodes of relative stillstand or falling sea-level and enhanced wave erosion during the overall transgression. Fining-up grain-size trends and deepening-up facies trends occur above ravinement surfaces and are interpreted as transgressive packages. Secondary unconformities within these packages again imply temporary pauses or reversals of the transgressive trend.

Biotic vs. abiotic carbonate precipitation in Lake Kournas (Crete)

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Microbialites, complex organosedimentary structures, arise from intricate interactions between microbial communities and the environment, sparking a debate over the biological versus abiotic origins in the fossil record. Recent fully abiotic experiments challenging the identification of past life traces have blurred the distinction between biological and non-biological processes. To navigate this, modern environments where microbialites are presently formed, like Lake Kurnas in Crete, can offer valuable insights.

As the sole large freshwater lake in Crete, Lake Kurnas exhibits favourable conditions for carbonate precipitation, with short sedimentary cores revealing primarily micritic carbonates. These carbonates result from photosynthetic activity by phytoplankton, especially diatoms, prevalent in the water column. Aquatic vegetation, particularly Characeae, further contributes to carbonate deposition.
Microbialites outline the lake's shoreline, being more prominent in the northwest and southern regions. Initially resembling abiotically precipitated carbonate crusts, closer analysis employing petrography, SEM imagery, and µ-XRF reveals filamentous cyanobacteria and abundant EPS as crucial contributors. Endolithic bacteria facilitate substrate colonization, forming microbial mats of varying thickness. Structures for "trapping and binding" intermingle with low-Mg micritic carbonates, enclosing cyanobacteria filaments, aligned perpendicularly to laminations, indicative of growing direction. Though DNA extractions are so far inconclusive, the potential presence of heterotrophic microbes and SRB cannot be dismissed. Summer seasons witness heightened phytoplankton and cyanobacterial activity and, thus, the different observed fabrics are most probably related to seasonal changes in productivity and lake water level. Further investigations are warranted, but this initial model aligns with analogous systems, such as Lake Pavillon in Canada.

Nature and origin of pinstripe laminated fine-grained strata deposited by turbidity currents

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Planar-stratified, fine-grained (silt-clay) strata makeup a significant part of the sedimentary record, ranging from continental lacustrine systems to the D-division in deep-water turbidites. Despite its commonality the origin of the lamination, and in particular the origin of the distinctive textural banding that forms the lamination, remain a source of much debate. Detailed analysis shows the banding to consist of rhythmically alternating silt- and clay-rich layers – silt-rich layers are well-sorted and as thin as a single silt-grain thick. Mud-rich layers consist of clay with dispersed silt grains and typically are a few 10s – 100s of micrometres thick. Moreover, where traced along strike, both types of laminae typically show little change in thickness for up to at least a few 10s of metres laterally. The spatial extent of the lamination suggests spatially ~ uniform transport/depositional conditions, and its thinness the involvement of rhythmically alternating processes operating in the near-bed region immediately above the bed. Here it is suggested that in the mm- to sub-mm-thick viscous sublayer at the base of a hydraulically smooth turbulent flow, a combination of high fluid shear and sediment concentration leads to shear thinning and enhanced mobility in the lower part of the flow, and for silt to settle to the bed depositing a well-sorted silt lamina. As silt settles and clay-size sediment increases in concentration, hydrodynamic lubrication forces strengthen and reduce mobility of the near-bed part of the flow. This condition is then perturbed by a bedward-directed outer flow disturbance that dramatically increase frictional stresses and effective fluid viscosity and ultimately shear jamming that causes gelling and deposition of a poorly sorted clay-rich layer. This, then, is followed by restoration of a viscous sublayer and accumulation of the silt-rich part of the next layer. This rhythmic process then continues and builds-up the laminated deposit.

Provenance and processes: clay mineral insights in Upper Pleistocene central Iberia at La Malia rock shelter

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The Quaternary sedimentary sequences that comprise archaeo-paleontological sites are the result of the interaction of different processes over time. The variation in the influence of one process over another will determine a complex sedimentary sequence that responds to local and regional controls. This study focuses on demonstrating the utility of clay minerals as a tool to break down the processes involved in the formation of sedimentary units. For this purpose, the La Malia shelter site has been examined (Tamajón, central Iberia), with a sedimentary sequence from the Upper Pleistocene that encompasses the periods of MIS 3 and MIS 2.

Throughout the sequence, varying amounts of illite, smectite, kaolinite, and chlorite have been detected. The finer-grained microfacies, identified as loess sediments, exhibit significantly higher proportions of smectite compared to other clay minerals. In contrast, the more conglomeratic microfacies of grain-supported slates present the lowest amount of smectite. Similarly, the microfacies associated with runoff processes reveal a relatively variable amount of smectite. The analysis of these minerals extends to the different surrounding soils, which are potential source areas. Here, the absence of smectite stands out, suggesting that this mineral is introduced into the system through aeolian processes with a source area beyond 20 km away.

From these data, it has been identified that during more arid periods, aeolian processes prevailed, resulting in a greater deposition of smectite. In contrast, during wetter phases, fluvial processes took on a greater role, eroding previous strata and depositing new surrounding sediments. In intermediate periods, surface runoff processes, being less erosive, lead to the resedimentation of components from previous levels, mixing them with new sediment contributions. Additionally, through the correlation of the sequence with other deposits, a period of regional aridity has been confirmed prior to the Last Glacial Maximum in the central Iberian Peninsula.

Analytical bias for geochemical provenance interpretation: XRF vs. ICP-MS/OES

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Geochemical measurements for provenance from different methods will give results of different precision and accuracy. This may pose a challenge to the comparison of data as it can indicate geochemical sample groups that are unrelated to provenance. Here we demonstrate differences in apparent chemical composition for XRF and ICP-MS/OES data for the same siliciclastic samples from the Triassic Buntsandstein Group in Germany. All samples were prepared identically for both methods, except for complete sample dissolution prior to ICP measurements and use of fused tablets for XRF analysis. Our results demonstrate partly higher XRF-based concentrations for Na_2O than for ICP-OES-measured data. For K_2O, XRF data typically generate lower concentrations than ICP-OES. Mostly this leads to minor differences in K_2O/Na_2O that may be related to different feldspar types in sediment-catchment areas. Among trace elements, Zr was partly have more than 100 % higher values for XRF than ICP-MS data. This may influence Zr/Sc and other zircon-related indices. For Ti, concentrations from the XRF and ICP laboratories at Jena are similar, but a dataset from other laboratories reveal higher values from XRF than ICP-OES analysis, potentially affecting the mafic-felsic indicator Ti/Nb. Finally, yttrium seems rather unaffected by analytical choice, so effects on for instance the felsic-mafic indicator Y/Co and the zircon-related Y/Zr may base on other elements in the indices. Deviations in Zr concentration may be due to incomplete dissolution prior to ICP-MS measurement. For other elements, analytical bias is more plausible. Due to potential bias, comparison of data from different methods may cause artificial geochemical groups. This also is relevant for discrimination schemes that are constructed based on data from specific methods. To conclude, data produced with different analytical methods and in different laboratories should be compared with care, as both oxide and element concentrations may differ significantly.

Paleogene Depositional and Geohistory Modelling of Nortwestern Margin of India Plate

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This paper deals with the microfacies analysis and depositional modelling of the Paleogene rocks of the Potwar Basin, northwest Himalayas. The larger benthic foraminiferal biostratigraphic information has been used to constrain the ages of the Lockhart, Patala, Nammal, Sakessar and Chorgali formations. The detailed microfacies analysis suggests that depositional architecture of the Palaeogene sediments in the study area is consistent with the distally steepened ramp settings. Inner ramp, middle ramp, ramp-sloe and deep basinal conditions were prevailing on the northwestern margin of the Indian plate. The sediment thickness variation and relative sea level information in different time slices were used to construct a geohistory model of the study area. This model has provided valuable information regarding the role of tectonics (subsidence and uplift) and relative/ or eustatic sea level variation (rise and fall), causing flooding and exposure of the platform. In the study area, the subsidence is dominating the northwest while uplift is manifested in the eastern part of the Potwar basin. During the Late-Paleocene (Thanetian) deepening of the basin; causing deposition of the Lockhart and Patala formations is attributed to the lithospheric flexural subsidence caused by initial loading of Asian plate rocks onto the Indian margin and argues for early Paleocene collision with Asia. During lower Llherdian 2-Middle Lllerdian 2, exposure-flooding events in the Potwar Basin are dated as 55.2 Ma and 54.2 Ma; a consequence of local tectonic variation during the deposition of Nammal Formation. The microfacies of the Sakessar and Chorgali formations show a shallow inner ramp to proximal middle ramp settings during middle Lllerdian 2, across the basin. The middle Cuisian biostratigraphic constraints and microfacies information implies that complete closure of the basin has occurred around 50 Ma; as a result of both eustatic sea level fall and India-Asia collision in the Potwar Basin.

Integrating transitional flow signatures into hybrid event beds: Implications for hybrid flow evolution on a submarine lobe fringe

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In addition to turbidites and debrites, hybrid event beds are now recognized as a common occurrence in deep-marine environments. Yet, many variations in the standard H1–H5 facies model have been described since this model was introduced at the end of the noughties, with the role of transient turbulent flows, i.e. flows that are transitional between fully turbulent turbidity currents and fully laminar debris flows, being particularly enigmatic.

Based on a comprehensive dataset collected from the Silurian Aberystwyth Grits Group and the time-equivalent Borth Mudstone Formation in West Wales, United Kingdom, transitional flow signatures were integrated into the standard hybrid event bed model. These signatures include muddy sandstones and sandy mudstones with large ripples (formed by turbulence-enhanced transitional flows), low-amplitude bed-waves (formed by turbulence-attenuated transitional flows), and heterolithic lamination and banding.

The field data revealed that: (a) H1-divisions are generated by turbulent flows that form not only massive facies but also plane-parallel laminated and ripple cross-laminated facies; (b) H2-divisions are formed by transitional flows that form banded facies, but also facies with large ripples and low-amplitude bed-waves, as well as heterolithic facies; (c) H3-divsions are formed by laminar debris flows; (d) H4-divisions can form from both turbulent and transitional flows; and (e) H5-divisions can be hemipelagic or have muddy debris flow signatures.

Based on embedded Markov-chain analysis, the vertical stacking of facies in the five principal hybrid event bed divisions suggests a gradual transformation from turbidity current via transitional flow to debris flow (H1 to H3), followed by a repetition of this transformation in the H4 and H5-divisions, but in overall finer-grained sediment. Although the majority of measured beds was classified as incomplete, three new types of hybrid event bed could be defined: turbulent-flow dominated, transitional-flow dominated with H3-division, and transitional-flow dominated without H3-division.

Distribution of Particulate Organic Carbon in Experimental Turbidity Currents and Their Deposits

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The burial of organic carbon in marine sediments over geological timescales leads to a net drawdown of atmospheric CO2, aiding regulation of the long-term climate. It is increasingly recognised that the mass of particulate organic carbon (POC) transported by turbidity currents and buried in submarine fans (e.g., Bengal Fan, Congo fan) can be significant. However, it is vital to understand how turbidity current flow behaviour controls the transport and burial of POC to constrain the organic carbon burial efficiency of these flows. Moreover, POC consists of many different fractions, with varying densities, shapes, and sizes, that may control how it is transported and deposited by turbidity currents. Experimental turbidity currents containing 0.25-0.5 mm and 0.5-1.0 mm leaf and wood fragments were produced in an 11-m long flume to understand how different POC fractions are vertically segregated within turbidity currents, and if this vertical segregation pattern is different between powerful and weak turbidity currents. Ultrasonic Doppler Velocity Profilers at 4 m and 10 m were used to measure the flow velocity profiles and combined with syphon sampling to produce sediment and POC concentration profiles. The flow deposits were sampled every 2 m at 5 mm vertical resolution to measure the vertical and along-flow POC burial distribution.
Initial observations suggest fast, sandy flows can efficiently transport POC, with large amounts of POC transported out the end of the flume. For lower velocity, aggrading silt-sand flows POC is deposited in the silt bed above a clean sand bed, matching observations of POC distribution in natural sand-rich turbidite systems (e.g., Bute Inlet). Organic carbon analysis will establish the vertical and longitudinal POC trends within the flows and deposits, for the two POC types. These experiments will aid our understanding of how turbidity currents transport and bury organic carbon in the deep-ocean.

Human-induced transitions in the Nakdong River Mouth : A sedimentological perspective on Delta-Estuary Evolution

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The Nakdong River mouth serves as a dynamic and evolving ecosystem in response to natural coastal processes and sediment supply. Historically, the Nakdong River mouth has been characterized as a delta system, with barrier islands residing on the lower delta plain. Over the past four decades, significant human-induced alterations, such as the dam constructions of the Nakdong River, extensive dredging activities, and the operation of sluices, have dramatically impacted the Nakdong River mouth. Of particular interest are Doyo-deung and Maenggeummeori-deung, two integral components that constitute a distributary channel mouth bar system in the eastern Nakdong River mouth. A comprehensive dataset comprising aerial and satellite imagery, as well as data acquired through drone and RTK-GPS surveys, has been compiled to investigate the evolving shorelines and profiles. The dam constructions of the Nakdong River, with its engineered control over river discharge, have led to a diminished tidal prism and an upsurge in wave energy. Consequently, these factors have contributed to the formation and ongoing landward migration of Doyo-deung. The controlled river discharge has accentuated ebb currents, resulting in substantial erosion at the northern extremity of Maenggeummeori-deung. The sediment eroded from Maenggeummeori-deung, despite the overall reduction in sediment supply across the Nakdong River mouth, has emerged as a pivotal source of sediment for the growth of Doyo-deung. Thus, the Nakdong River mouth has transitioned from its natural deltaic system to a wave-dominant estuary system, marking a transformation predominantly instigated by human interventions.

Tuvalian (Late Triassic) environments and climate in the Western Tethys (Transdanubian Range, NW Hungary) – the aftermath of the Carnian Pluvial Episode: a sedimentological, palaeontological and geochemical approach

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A Late Triassic hyperthermal event, labelled Carnian Pluvial Episode (CPE) was associated with volcanism, global warming, enhanced hydrological cycling and C-cycle perturbation, as evidenced by multiple negative carbon isotope excursions (NCIE) in the Julian 2–Tuvalian and significant biotic turnovers. We investigated the CPE response of mixed carbonate-clastic successions from the Transdanubian Range (TR) that was part of the Western Tethys shelf formed by intraplatform basins and carbonate platforms. Palynology, ostracod studies integrated with sedimentology, $\delta^{13}C_{org}$, clay mineralogy, and major and trace element analysis depicted the late Julian 2 and Tuvalian depositional history. The onset of the CPE at the Julian 1–Julian 2 boundary was followed by oscillations in detrital influx, deposition of marls instead of carbonates, higher weathering intensity and a stepwise increase in hygrophytic plants with the maximum expansion of deltaic and mire habitats and drowning of carbonate factories in the late Julian 2. New chemostratigraphy integrated with palynological data helped defining the Julian-Tuvalian boundary (JTB) and this interval was marked by the most pronounced biotic change among ostracods across the CPE. Generally impoverished Julian ostracod assemblages was followed by a unique low-diversity euryhaline ostracod assemblage at the JTB that was linked to salinity driven stratification in intraplatform basins coinciding with a relative sea level fall. The Tuvalian marks the return of marine and marine-marginal conditions and transgression inferred from the diversification of ostracods and a predominantly upland, drought resistant palynological assemblage. The latter would indicate a shift back to drier climate yet geochemical proxies still indicate humid conditions, thus they mainly reflect increased distance from the shoreline. The decoupling of palynology and geochemical data implies that the CPE record in this part of the Western Tethys was complicated by local platform progradation episodes and sea level variations that were superimposed on the global climatic signal.

Can palaeosols reveal palaeoenvironmental variability of fluvial systems? A case study from the Upper Cretaceous, upper Bauru Group, SE Brazil

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Palaeosols are common in sedimentary successions of continental origin; they can comprise most of the thickness of accumulated successions. Neglecting or overlooking the palaeoenvironmental importance of palaeosols carries the risk of amalgamating distinct sedimentary units in a single description and interpretation, even when the depositional architecture, palaeoenvironment, and controlling factors governing the sedimentary processes are fundamentally dissimilar. This can undermine the accuracy of the interpretation.
This is the case of the upper part of the Bauru Group, a 100-150 m-thick Campanian-Maastrichtian red sandstone unit of fluvial origin, present over an area of c. 180,000 km2 in south-eastern Brazil. In this study, the palaeosols of this unit, which constitute 23-90% of the succession by thickness, are used to reconstruct the geometry of the depositional system, determine possible causes of its formation and its dynamic evolution, decipher palaeoenvironmental conditions, and discriminate depositional similarities and differences of this unit. Through the combined study of macroscopic, micromorphological, and geochemical aspects of the palaeosols and the sedimentary lithofacies, the upper part of the Bauru Group succession is separated into three areas: north-western, north-eastern, and south-eastern. Although these three areas are all characterised by similar lithology and sediments that were deposited by alluvial systems, they are characterised by different cyclical sequences of palaeosols and deposits, different dynamics of the sedimentary and pedogenic processes, different depositional architecture, different clastic source areas, and different climate. This research demonstrates the critical significance of the palaeosols for discriminating otherwise similar depositional units. Moreover, given that the geochronological and biostratigraphic data of upper part of the Bauru Group are ambiguous, this research questions the isochronous nature of this unit and defines a framework for geochronological dating (e.g., from pedogenic calcareous nodules) and in-depth palaeoenvironmental analyses of the palaeosols with which to address accurate stratigraphic, geotectonic and palaeontological studies.

PALAEOSOLS OF THE BARRA VELHA FORMATION AND THEIR RELATIONSHIP WITH STRATIGRAPHIC EVOLUTION OF THE SANTOS BASIN, BRAZIL

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The carbonate reservoirs of the Brazilian Pre-salt are made up of lacustrine deposits formed in an evaporative and alkaline lake with high concentrations of silica and magnesium. The typical facies comprise spherulites, shrubs, and Magnesian clays. At the marginal regions of the lake, reworked facies such as grainstones and packstones point to an energetic and fluctuating coastline. One of the main characteristics of these reservoirs is the various occurrences of paleosols, whose mineralogical properties bring environmental information at different scales. Based on the analysis of drill cores and thin sections from the Santos Basin, diagnostic features of paleosols were identified and described (horizons, structures, bioturbation, colours, dissolution, cementation, neoformation, and illuviation of clay minerals), allowing us to classify them as well-drained paleosols (WDP) and poorly drained (PDP). Thin sections, Scanning Electronic Microscopy, and X-ray diffractometry analysis show a mineralogical framework consisting predominantly of calcite and dolomite, with quartz and clay minerals (stevensite, kerolite, illite, gypsum) occurring subordinately. In addition, the Reflectance Spectroscopy technique was also used to identify kaolinite, montmorillonite, palygorskite, and vermiculite, which were relevant for characterising the mineralogical of paleosols. From an environmental point of view, well-drained paleosols (WDP) are rich in dolomite, overlying areas with karst porosity, suggesting a drop in lake level and long periods of subaerial exposure. In turn, poorly drained paleosols (PDP) are rich in organic matter, greenish-grey colours and minerals formed under reducing conditions. Such characteristics indicate palustrine regions (backshore) under the influence of saline waters rich in Mg, where the dolomitisation of carbonates occurred due to high evaporation rates. Based on these observations, a model of the evolution of the Aptian landscape of the Santos Basin is proposed here. Thank the ANP nº CW266675 and Brazilian National Council for Scientific and Technological Development (CNPq) for the productivity grants (process 310734/2020–7 and 311491/2019–7).

A Geometric Theory for the origin and motion of sand dunes

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In this study, a new theory for the spontaneous formation of sand dunes and related bedforms is proposed. The theory is based on the concept that smaller accumulations of sediment outpace larger ones due to differences in surface-to-volume ratio. From this geometric principle, it follows algebraically that for any nonzero bedload transport, the bed (sediment-covered surface) must be tilted upward along the currents direction, forming ripples and dunes. These ideas are validated by making the first-ever accurate predictions of dune speeds (migration rates) that are derived solely from measurements of dune geometries, specifically stoss side (s) and lee face length (l). This prediction has very high statistical significance: R2= 0.92, P = 2.0e-122, n=250. The geometric relationships defined here also predict the backwards migration of antidunes and explain the horned barchan dune and mirrored parabolic dune shapes.

What controls the deposition of dune fields in rift basins?

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Conventional facies models for aeolian deposits are largely based on systems deposited in broad, largely unconfined basins. Aeolian systems in rift basins are strongly controlled by the topography, localised wind patterns, and the available sand supply. This study quantitatively analyses several controlling factors for 69 modern arid rift basins in North America to determine what controls the presence and distribution of dune fields within them. It uses a combination of satellite imagery, SRTM derived terrain data and the high-resolution Real-Time Mesoscale Analysis (RTMA) model which provides unique information on wind speed and direction with unprecedented spatial and temporal resolution.

The following parameters were measured: dune orientation, size and type; fluvial drainage area; basin area; basin orientation, and the elevation difference between basin plain and adjacent mountain tops. The areal extent of playa lakes in the upwind areas of the dune fields and the lithology within the fluvial drainage areas was analysed to study sediment sourcing. The near-surface wind patterns were calculated from the RTMA model on a 3 km grid at hourly timesteps.

In basins that contained aeolian deposits, wind directions were predominantly parallel to basin orientation resulting in dune transport along the basin axis. Mountain ranges surrounding the basins mostly comprised strata that, when weathered, produces sand grade material (i.e., granites). Winds were on average slower and displayed higher variabilities than winds over the basins that lacked aeolian deposits. Fluvial outwash plains occurred in all basins and supplied sediment to dune fields. These and desiccated lakes further occurred in the upwind areas of all dune systems. This suggests that in addition to favourable wind patterns, dune formation is linked to the availability of large sand volumes that are released when lakes and rivers desiccate. The dune fields are dominated by transverse dunes, linear and star dunes are commonly absent.

An extended Upper Aptian succession from the southern NeoTethys (Tunisia) – high-resolution isotope stratigraphy and a siliciclastic-dominated lowstand

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New, high-resolution carbon-isotope profiles combined with biostratigraphy constrain a platform to basin transect of the Aptian stage across Tunisia. The southern platform domain (Djediri and Oum Ali) reaches a thickness of approx. 270 meters, and in the northern, basinal sections (the Sidi Hamada and Bir Attay sections, Serdj mountain) the Aptian deposits reach a total thickness of 850m. The excellent exposures allowed for a detailed facies description, which in combination with the time control, formed the basis for a high-resolution sequence stratigraphic model. Two long-term sequences are distinguished. The first one spans the Early Aptian and the early part of the Late Aptian, is carbonate dominated and includes the OAE 1a event around its maximum flooding surface. The second one covers the remaining part of the late Aptian, is dominated by siliciclastic sandstone deposits, and has an oolitic-dominated lowstand deposited as a shelf margin wedge. This is followed by an uppermost Aptian/lower Albian transgression and the return of a carbonate-dominated sedimentation. Comparison of this Southern NeoTethys section with two equally thick Northern NeoTethys sections (Vocontian Trough in south France and Aralar platform in north Spain), shows a remarkable similarity of the isotope stratigraphic signatures in these three locations. In addition, the Tunisian lowstand sands and ooliths, occur exactly in the interval that has been proposed as a cold phase in the Spanish section (Millan et al., 2014). The combined facies and isotopic evidence, provide thus further evidence for the proposed Late Aptian glacio-eustatic drop and rise that controlled sedimentation patterns in the margins around the NeoTethys Ocean.

The Cordilleran Carbonate Conundrum: new preliminary insights on the Paleozoic Cache Creek terrane, northern Cordillera, Canada

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The northern Cache Creek terrane comprises an extensive, warm-water, shallow carbonate platform that persisted from the earliest Carboniferous to the end of the Permian. The paleoenvironments recorded by these limestones suggest that this vast platform remained at a relatively stable water depth for close to 100 million years. This stability seems to contradict the currently accepted model for the origin of this terrane as a seamount(s) or plateau that formed far outboard in the Panthalassa Ocean long before its accretion to the North American margin in the Jurassic. This model was largely based on select fossils, predominantly fusulinaceans and conodonts, that were deemed to be exotic to the adjacent terranes and to North America. Recent tectonostratigraphic studies have demonstrated that the existing terrane framework is inaccurate, leading to unreliable tectonic reconstructions. For example, Guadalupian to Middle Triassic ophiolites that were believed to represent ocean floor basement to the Cache Creek terrane are demonstrably younger than the early Carboniferous inception of the carbonate platform and formed in a supra-subduction zone environment. Furthermore, recent re-evaluation of Cache Creek conodonts shows a lack of typical Tethyan species, demonstrates a high degree of heterogeneity within the conodont faunas, and suggests that, as a whole, the faunal assemblage is similar to those reported from other terranes along the North American margin. Herein, we re-investigate the origin of the Cache Creek terrane through a combination of paleontological, sedimentological, and geochemical analyses on the limestones, exploring alternative explanations for its relatively uniform composition. Specifically, we are targeting proxies of continental margin proximity including the presence/absence of pollen spores, the occurrence of red beds, and the abundance of terrigenous trace metals. This will provide insight into the origin and translation of the Cache Creek terrane and refine the terrane model for the Canadian Cordillera.

Fingerprints of Tectonics and Climate Change in the Detrital-Zircon U-Pb Record of the Deep-Sea Bengal Fan

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The Himalayan-sourced Ganges-Brahmaputra (GB) river system and the deep-sea Bengal Fan represent Earth's largest source-to-sink sediment-dispersal system. The Bengal Fan is a "one-of-a-kind" in terms of scale, the largest clastic sedimentary deposit on Earth, as well as a globally significant CO_2 sink. IODP Expedition 354 (2015) drilled a 7-site transect in the middle Bengal Fan, ~1400 km south of the shelf margin. Our recent work has developed a detrital-zircon (DZ) U-Pb provenance record from IODP 354 cores and modern river samples, which provides insight into a number of issues.

Bengal Fan turbidites record the strong tectonic and climatic forcing associated with the GB system. First, India's NNE motion relative to Asia places IODP 354 drill sites ~800 km and ~400 km farther south from the GB delta at 20 Ma and 10 Ma, respectively: prior to 10 Ma, these locations remained too far away for significant sand-sized turbidite deposition, whereas after 10 Ma thick sand-rich turbidites are common. Second, after ~4000 km of fluvial and turbiditic sediment transport, the DZ U-Pb record faithfully represents Himalayan and Tibetan sources, especially the <300 Ma ages from the Tibetan Gangdese arc, which is present by the Early Miocene, and increases in significance over time. Third, we infer the signals of climate change in the Plio-Pleistocene record. For example, sand-rich turbidites accumulated only during glacial periods of low sea level when river mouths connected directly with slope canyons. Moreover, sand-rich turbidites display different proportions of DZ U-Pb age groups than modern river sands, especially after the Plio-Pleistocene transition. We speculate these differences reflect pre-glacial vs. glacial sediment production, with Miocene and early Pliocene periods dominated by monsoon rains and production of sediment from lower elevations, and the Plio-Pleistocene glacial periods dominated by higher-elevation cold-climate and glacial processes.

Palaeoenvironments of the St. John's and Signal Hill Groups of Newfoundland, Canada, and their influences on Ediacaran macrofossil distribution

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The Ediacaran macrobiota provide insights into the early evolutionary history of animal life. However, environmental controls on Ediacaran macrofossil distribution remain poorly resolved. In relatively deep-marine deposits of Newfoundland (Canada), rapid turbiditic burial events separated by long intervals of sedimentary stasis facilitated preservation of a diverse assemblage of Ediacaran macrofossils. Conversely, shallow-marine environments within the same basin contain no macrofossils, despite evidence for Ediacaran organisms at comparable bathymetries in coeval global localities. The paucity of fossil content has left Newfoundland shallow-marine deposits largely understudied. Here we examine the shallow-marine deposits of five formations of the St. John's and Signal Hill groups of Newfoundland: the Fermeuse, Renews Head, Cappahayden, Gibbett Hill and Ferryland Head formations, and test hypotheses regarding fossil–facies relationships via sedimentological and palaeontological analysis. We recognize a wide variety of sub-environments ranging from distal prodelta, delta front, and delta top facies with variable tidal, storm- and wave-dominated input. Confined sedimentation within channels and delta lobes is often energetic and erosive, causing reorganization of sedimentary bedsets. In contrast, laterally adjacent, unconfined, fine-grained heterolithic facies archive calmer waters amenable to the preservation of "true substrates" – surfaces at the sediment-water interface that have the potential to host surficial organisms and preserve them as fossils. Such facies host a range of abiotic and microbial surface textures, yet lack macrofossils. Given the presence of macrofossils in potentially analogous deltaic facies of a similar age in Russia and Australia, Ediacaran macrofossil preservation in shallow-marine siliciclastic settings may therefore be highly dependent on sedimentation rate, which impacts the time exposed on the seafloor, and depositional setting, which affects the tendency to rework or preserve a given substrate. Assessments of Ediacaran diversity through space and time require knowledge of the spatial distribution of environmental controls, including specific sedimentation states that may underpin fossilisation.

Vestiges of former gas hydrate in sedimentary successions

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Gas hydrates (clathrates) are solid compounds consisting of crystalline water and compressed gas, mostly methane. They are commonly found in marine sediments along continental margins at specific pressure-temperature conditions and represent a major energy resource. Changes of pressure or temperature, e.g. caused by ocean warming, sea-level drop or burial, destabilize clathrates. Extensive gas hydrate dissociation and associated methane release may lead not only to regional catastrophes, such as submarine slope failures, but also to accentuation of global warming and ocean acidification. Some of the most severe greenhouse effects, e.g. the Paleocene-Eocene Thermal Maximum, and biotic crises, e.g. the end-Permian extinction, are assumed to have been related to global dissociation of gas hydrates. However, these assumptions are based on geochemical modelling and circumstantial reasoning, since hydrates are not preserved in the rock record and hydrate-related features have not been reported from the sedimentary record encompassing these events. Still, gas hydrates have surely been present in marine sediments in the Phanerozoic and their geological record must be underrepresented. Therefore, recognition of vestiges of former clathrate represents an important frontier in geoscience for the understanding of the role of gas hydrate in geological history. Here, we present a review of sedimentological and geochemical features, which have been linked to former gas hydrate presence and we analyze the perspectives to identify hydrate-derived rocks in the geological record.
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REVISITING THE LOWER TRIASSIC BUNTSANDSTEIN GROUP, UPPER RHINE GRABEN AREA (FRANCE – GERMANY): A COMBINED OUTCROP AND CORE APPROACH

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The Buntsandstein Group, Upper Rhine Graben, France – Germany, records more than 400 metres of dominantly sandstones, with subordinate conglomerates and lesser fines; and is interpreted as a braided fluvial system deposited in an arid environment. The same is now considered one of the main reservoirs of the hot brine found in the region, where there is a highly anomalous geothermal gradient, from which can be produced not just geothermal energy, but also heat, and lithium carbonate.

In order to revisit the Buntsandstein Group, this study focused on two data sources, outcrop and core. The outcrops are relatively closely distributed, considering the regional-scale spreading of the units, scattered throughout the Western shoulder of the Upper Rhine Graben (URG), from the Vosges Mountains (France), right through the Rhineland-Palatinate (Germany). The core is from a geothermal well, drilled in the French domain of the URG, and records more than 400 metres of almost continuous stratigraphy, from the heavily bioturbated overbank-rich Permian fluvial deposits (Lower Buntsandstein Fm.); to the highly structured, interbedded fluvial and aeolian deposits of the Lower and Upper Grès Vosgien Fms. (Middle Buntsandstein).

In the Grès Vosgien, fluvial architecture (which record overall high permeability) dominates over aeolian (recording highly variable, but usually low permeability), in the lower two-thirds (c. 200 m); with a gradual increase, not just of the frequency, but also thickness of the aeolian elements. This varies from less than 7% of the deposits in the lower Grès Vosgien (i.e., facies Trifels), up to 40% in the Upper Grès Vosgien (i.e., facies Karstal). This alternation between fluvial and aeolian architectural elements has been interpreted as controlled by allogenic (climatic) events. Here we propose an autogenic drive for this alternation, based on spatial distribution of fluvial channel avulsion; and suggest a new palaeoenvironmental interpretation, considering it a distributive system.

Sand injectites reservoirs - their importance during and beyond the energy transition.

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Sand injectites typically comprise deepwater depositional units which have been highly dewatered, remobilised and injected into mudstone host rocks. In some instances, remobilised sand was transported via fractures, breached the palaeoseabed and was deposited as an extrudite. The study of sand injectites therefore requires an understanding of how the sediments were deposited, buried, compacted, liquified, translocated and deposited – both within the hydrofractures that formed conduits to the seabed (forming dykes, sills, wings and saucer forms) and at the seabed.

The resulting complex 3D relationships between subvertical dykes, inclined sills, wings and saucer-shaped forms can be difficult to conceptualize and model. Here we illustrate the use of novel methods to model sand injectite facies, based on outcrop derived data, interpretation and concepts. We show the application of those models to aid the further understanding of the dynamic behaviour of sand injectite reservoirs.

More than 3.3 billion barrels of oil has been produced from sand injectite fields in the North Sea. Significant hydrocarbon exploration, production and possible CCS potential exists in formations impacted by sand injection. The presence of some injectite features (mainly dykes and wings) significantly increases vertical connectivity within the gross reservoir interval and is often the reason sand injectite reservoirs have large hydrocarbon column heights - when compared to structural or stratigraphically trapped reservoirs.

This poses challenges with respect to how these fields can be optimally developed, but by integrating representative 3D models and the correct development strategy sand injectite fields can produce for long periods at low water cuts. This factor is potentially useful beyond the point we use oil as a combustible fuel, as sand injectite reservoirs can produce at lower carbon intensities than fields that rely on injection support.

Using Ground Penetrating Radar (GPR) to Investigate the Deposits from the Storegga Tsunami in north-eastern Scotland

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A submarine landslide on the edge of the Norwegian shelf that occurred around 8,150 ± 30 cal. years BP, triggered a major ocean wide tsunami, the deposits of which are recorded around the North Atlantic, including Scotland. Ground-penetrating radar (GPR) is used here to investigate tsunami sediments within estuaries on the coast of north-eastern Scotland where the tsunami waves were funnelled inland. Interpretation of the GPR at Wick suggest that there has been a miscorrelation of Holocene stratigraphy based on boreholes. Around the Dornoch Firth the tsunami deposits are up to 1.6 m thickness which is exceptionally thick for tsunami deposits and more than twice the thickness of the 2004 IOT or 2011 Tohoku-oki tsunami deposits. At Ardmore the tsunami appears to have overtopped a beach ridge with a thick sand layer deposited inland at Dounie partly infilled a valley. Later fluvial activity has eroded into the tsunami sediments locally removing the sand layer. At Creich, on the north side of the Dornoch Firth, the sand layer is exceptionally thick and mapping of sand layers shows lateral thickness changes of over 1 m, with lateral thickness changes attributed to a combination of infilling an underlying topography and later reworking, possibly by tidal inlets.

Why are star dunes rarely recognised in the rock record?

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Star dunes are the tallest dunes on Earth and are amongst the largest and most spectacular dynamic landforms. Although they are widespread in modern sandy deserts star dunes are rarely recognised in the rock record probably due to a lack of suitable models. This stratigraphic study of a star dune in Erg Chebbi, Morocco, uses ground-penetrating radar (GPR) and optical dating to investigate the dune's age and structure. The results show that the dune has developed recently and grown rapidly to create a 100 m high dune within the past thousand years, and that has been migrating westwards at a rate of around 0.5 m/yr, confirming that star dunes can migrate. At the base of the dune there is a period of around eight thousand years that appears to lack sand accumulation, probably due to stabilization of the dunes during the African humid period (AHP). We present a new model for the structure of a star dune based on a geophysical and geochronological investigation. The resulting model of star dune structure includes extending and reversing dune arms, converging arms that wrap around the dune, overlain by multiple bounding surfaces and large sets of cross-strata formed by the main dune slipface. Because sand dunes are preserved from the bottom-up the strata from the arms that extend in the downdrift direction, as well as the arms that wrap around the dune and converge beneath the main body of the dune have a much higher preservation potential than the dunes characteristic peak. Individual structural features in star dunes are similar to those from linear or barchanoid dunes, likely leading to misidentification in the rock record, but the suite of features we describe will permit identification of star dunes in future studies of the rock record.

The protracted onset of deep-marine ichnofacies

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The success of ichnology in paleoenvironmental reconstructions has relied on time-independent models. This approach has emphasized behavioural convergence at the expense of macroevolutionary innovations, as illustrated by the ichnofacies model. However, calibrating trace fossil models according to geologic time is fundamental for applied ichnology, a point illustrated by the protracted onset of deep-marine ichnofacies. The deep sea is characterized by the Zoophycos and Nereites ichnofacies, which illustrate continental slope and basin plains, respectively. Zoophycos is the typical ichnogenus of the Zoophycos Ichnofacies, but Phycosiphon, Chondrites, and certain ichnospecies of Nereites may be present. This ichnofacies is the most problematic of all ichnofacies since in practice its recognition is somewhat dependent on the identification of Zoophycos itself. This is further complicated by the broad paleobathymetric range of this ichnogenus, which has experienced a seaward migration throughout the Phanerozoic. The earliest record of the Zoophycos Ichnofacies in a slope corresponds to the Middle Ordovician, although the oldest presence of Zoophycos in such environments occurs in the early Silurian.
Ediacaran deep-marine deposits are host to low diversity suites of simple trace fossils, whereas an increase in morphologic complexity is apparent during the Cambrian. However, both time periods reflect exploitation of microbial mats rather than the diagnostic farming and trapping strategies of the Nereites Ichnofacies. The main architectural designs of graphoglyptids were established in the deep sea by the Early Ordovician, recording the appearance of the Nereites Ichnofacies. The distinction between the Nereites and Paleodictyon ichnosubfacies, with the former characterized by the dominance of feeding traces in muddy turbidites and the latter by graphoglyptids in sandy turbidites, can also be tracked back to the Ordovician radiation. The Ophiomorpha rudis ichnosubfacies, which is dominated by crustacean and echinoderm burrows in proximal amalgamated sandstone units, is a product of the Mesozoic Marine Revolution.

A tale of meanders, burns, and chutes: Archaeo-sedimentology of Old Aberdeen

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Villages, towns, or cities are commonly located on riverbanks on which human activity is focused. River channels may appear stable on human life timescales, but geological and geomorphological studies indicate that the morphology, location, and orientation of fluvial systems change through time. Studies that investigate planform geometry of fluvial systems shed some light on this change. These studies, however, rely on satellite and aerial imagery to analyse river planform geometry and patterns. These data sources have an inherent temporal limitation from when the imaging platform was launched, and data was collected. Architects, geographers, and lithographers, however, have created detailed maps for centuries. Many of these maps describe past landscape and city plans that use strategic water resources. These maps also provide key geographical insights into fluvial systems that otherwise remain unknown. Historical maps, integrated with subsurface data such as ground penetrating radar (GPR) and remotely sensed imagery, facilitate a greater understanding of the spatio-temporal evolution of meandering fluvial systems that migrate over timescales that cannot be observed with the earliest available satellite imagery data.

Herein, we present a study that integrates geospatial data obtained from maps that span nearly 4 centuries with subsurface data collected from GPR methods, to investigate the geomorphological evolution of a meandering section of the River Don in Aberdeen, Scotland. Historical maps provide a spatio-temporal context and understanding that modern one-dimensional (e.g., borehole) or even two-dimensional (e.g., GPR) data cannot elucidate. The results from this study highlight the importance of integrating historical data with modern collection and analysis techniques to enhance our understanding of fluvial systems that do not change on timescales relevant for societies. This archaeo-sedimentoligical approach would not be possible without historical maps made available, thereby, open geoscience data is critical to future investigations and should be embraced as such.

The use of ichnology in the evaluation of controls on deposition within an Eocene-aged mixed influence deltaic system: the Mangahewa Formation, Taranaki Basin, New Zealand

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The Middle to Upper Eocene Mangahewa Formation forms a broadly NE-SW-oriented coastal facies belt which constitutes the main hydrocarbon reservoirs in the Taranaki Basin, New Zealand. The Mangahewa Formation represents deposition within a deltaic setting that displays variable influences of wave, fluvial and tidal processes, with wave and fluvial processes dominant. Broadly, the >1000 m thick formation constitutes a 2nd-order progradational succession overlain by a retrogradational succession composed of 3rd- and 4th-order sequence sets. Arcuate delta and beach-ridge geometries can be imaged using seismic attribute data. Landwards of the shoreline systems, lower delta plain with associated fluvial channel facies belts dominate.

In the Pohokura Field and Turangi area, well developed, wave-dominated, fluvial influenced, tide-affected (Wft) shoreface packages dominate the reservoir sections. The shoreface strata comprise cross-stratified sandstone-rich deposits with relatively high degrees of bioturbation and high ichnodiversity, dominated by Ophiomorpha nodosa, Ophiomorpha irregulaire, Dactyloidites isp., Conichnus isp., and very large Asterosoma isp. Trace-fossil analysis enabled the subdivision of the shoreface strata into Upper, Middle, and Lower Shoreface (proximal and distal) packages. High stress levels are characteristic of the Distributary Channel packages, which are either non-bioturbated or reveal sparse bioturbation by Skolithos linearis. Abundances of Ophiomorpha nodosa preferentially reworking clay drapes characterize the uppermost parts of tidally influenced channel packages locally. Firmground Thalassinoides isp. (Glossifungites ichnofacies) are common below channel bases.

Ichnologically, the back barrier lagoonal heterolithic strata, many interbedded with coal beds, reveal highly stressed ichnofaunas. They were either non-bioturbated, or contain Planolites montanus, rare Chondrites isp. and/or Thalassinoides isp. Heterolithic strata representing down-drift strata also reveal similarly stressed ichnofaunas, with many monospecific trace-fossil assemblages characteristic. In contrast, non-stressed Delta Front heterolithic deposits are characterised by intense bioturbation with maximum ichnodiversity. Trace-fossil assemblages include Thalassinoides isp., Teichichnus rectus, Phycosiphon incertum, Palaeophycus tubularis, Chondrites isp. and Schaubcylindrichnus isp.

Sequence stratigraphy of the Neoproterozoic Throssell Range Group, Western Australia: evolution and copper mineralization of a Rodinian margin.

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The Tonian Throssell Range Group is a ca. 3.5-km-thick fluvial-marine succession that accumulated on the eastern Pilbara craton. It contains a nearly complete record of margin evolution along this segment of Rodinia and may capture the onset of Neoproterozoic Earth oxygenation. The Throssell Range Group is also economically important because it hosts the Nifty copper deposit, which has produced > 700,000 tonnes of copper. Its depositional age is bracketed between a detrital zircon age of 911 ± 23 Ma and the U-Pb zircon age of cross-cutting intrusions associated with Rodinia breakup at 837 ± 6 Ma. However, a newly acquired U-Pb age of 1323 ± 32 Ma from diagenetic apatite at the base of the succession suggests a much longer history.

Logging of new diamond drillcore (n=14) shows the Throssell Range Group is composed of four previously unrecognized unconformity bounded sequences. Sequence 1 consists of alluvial fan, braided river, and deltaic deposits that are interpreted to record foreland basin development during the collision of the Pilbara and North Australian cratons. Sequence 2 is composed primarily of clastic shoreface and storm-deposited shelf facies that accumulated on an open margin. Sequence 3 contains upwelling-related black shale, phosphorite, and chert and is the only sequence with copper mineralization. Sequence 4 reflects the establishment of a rimmed platform dominated by microbial carbonates.

Historically, the Throssell Range Group is thought to record rift-to-drift deepening associated with Rodinia breakup, but its sequence stratigraphic architecture and new geochronology suggest an older history that began with Rodinia amalgamation. The occurrence of upwelling-related phosphorite in Sequence 3 necessitates suboxic bottom waters, which may have developed during the beginning of the Neoproterozoic Oxygenation Event. Such a dramatic change in Earth's surface Eh was also probably critical for mobilizing copper to produce economically significant sediment-hosted deposits.

Holocene hydroclimate reconstructions from playa-lake sediments in southern Iberia: a case study in Laguna Salada de Campillos (Málaga)

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Ephemeral wetlands are highly sensitive to both short-term and long-term hydroclimate changes. The sedimentary sequences of the numerous playa-lakes scattered across the lowlands of the southern Iberian Peninsula can yield valuable insights into the paleoenvironments of this region. In this study, we investigate the geochemistry and mineralogy of a 4.6-meter sediment core from Laguna Salada de Campillos (Málaga province). Our analyses include 14C-dating, mineralogical examinations, as well as major and minor element and isotopic analyses of gypsum hydration water. The sediments of Laguna Salada encompass brownish to blackish clay, silt, coarse quartz sand, and sporadic occurrences of gypsum, including fine gypsum sands and occasionally millimeter-sized gypsum crystals. Our preliminary analyses focus on the upper 50 cm, spanning from 1250 to 2022 CE. Three distinct depositional phases have been identified based on the presence of gypsum and the δ18O and δ□H values of the paleo-lake water, reconstructed from the isotopic composition of gypsum hydration water. From 1250 to 1350 CE, gypsum is abundant and the δ18O and δ2H values of the paleo-lake water were relatively high, suggesting the existence of a shallow, likely ephemeral system, resembling the modern Laguna Salada. These results indicate that arid climate conditions prevailed during the Medieval Climate Anomaly in this region. Subsequently, from 1350 to 1850 AD, during to the Little Ice Age, the climate was wetter, and the lake became permanent at least during some stages, as evidenced by the reduced presence of gypsum and lower δ18O and δ2H values of the paleo-lake water. Finally, from 1850 to 2022 AD, the lake turned into an ephemeral system again, significantly impacted by anthropogenic activity in its catchment. Further analyses of the deeper core sections hold the potential to unveil Holocene hydroclimate changes in this region.

Seismic Geomorphology of Two Basin Fan Systems Offshore West of Shetland Revealing Contrasting Paleoenvironments and Sedimentary Processes: Eocene versus Pleistocene.

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This study combines seismic reflection data and well logs to apply seismic geomorphology principles, and significantly enhance the visualisation of the complex subsurface geology of the Fareo-Shetland Channel across an area located 120 km West of the Shetland coast.
The study area is characterised by the presence of a prominent unconformity marking the contact between Late Eocene turbiditic basin fans, deposited by a deltaic prograding system, and overlaying glacigenic deep-water fans, associated with a Pleistocene trough-mouth fan system. Previously characterised mainly by bathymetric and sparse sub-bottom profiler data, these younger fans, partially exposed on the seafloor, have been reinterpreted through seismic facies analysis. This work links seismic facies to depositional systems and processes, revealing the internal geometry of the glacigenic basin fans in unprecedented detail while also providing new insights into the evolution of Late Eocene fans. This allows for a direct comparison of deep-water deposits formed in contrasting environmental conditions: a greenhouse setting for the Late Eocene fans and an icehouse setting for the Pleistocene fans.
At the regional scale, the results offer new perspectives on the mechanisms of deep-water sediment delivery processes associated to the development of these basin fans. This provides new constraints on the West of Shetland margin evolution helping to refine the Late Eocene and Pleistocene depositional models, despite the extensively studied region. At a more local scale, this study highlights the high variability in geological features over relatively short horizontal and vertical distances. This has implications for both paleo-reconstructions and marine engineering studies.

Caught in the act: Knickpoint and plunge pool preservation at a submarine channel base

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The geomorphology at the base of active submarine channels is marked by erosional features, such as knickpoints and plunge pools. Typically, these geomorphic features have a low preservation potential as they are highly dynamic and migrate upstream, and repeated cycles of cut-and-fill result in smooth, planar, channel bases in the stratigraphic record. The result is an approximately consistent longitudinal channel thickness. As their presence in ancient channel-fills has rarely been documented, their importance in submarine channel morphodynamics requires further investigation. Here, we demonstrate that the transfer of these features to the ancient record is possible. We use 3D high-resolution seismic reflection data calibrated by several wells to assess a rugose submarine channel base surface with 100s m long and 10s m deep erosional features, and a channel-fill with marked longitudinal thickness variations. Large-scale channel incision patterns reflect a transient slope uplift controlled by far-field salt tectonics, which induced erosional flows. Local salt-related structural complexities in the channel slope created zones of preferential scouring and the formation of knickpoints and a plunge pool. A sudden switch from the high-energy erosional regime to a lower energy depositional regime, controlled by extra and/or intra-basinal factors, inhibited the upstream migration of the knickpoints. Furthermore, the formation and preservation of channel base rugosity with exceptional basal scours indicate that headward erosion processes did not operate rapidly, challenging the paradigm that knickpoint migration controls channel evolution. Our results show that the primary erosion of the main channel surface and long-term channel evolution are dominated by far more gradual processes. In addition, we speculate that the preservation of erosional features along channel bases could be more widespread than previously envisaged in dynamic slope settings.

Microbial fossilization by silica: new insights into a cretaceous chert

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Since the pioneering work of Barghoorn and Tyler on the well-preserved, silicified stromatolitic microbiota from the 2000 Ma-old Gunflint Formation, silicified microfossils have provided a good record of Proterozoic microbial life closely associated with microbialites. In contrast, such phanerozoic occurrences are considerably less common. This works reviews the fossilization process by silica permineralization with new data in the Huepac chert from the Late-Cretaceous Tarahumara Formation in northwestern Mexico. This succession includes stromatolites and associated synsedimentary chert containing a diverse inventory of silicified microbiota, among which diatoms frustules record one of the first incursions of non-marine diatoms. Vascular plant remains, fungi, arthropods, and diverse microfossils from cyanobacteria, algae, acritarchs, polen and spores are preserved by silica. The petrographic analysis shows microbial fabrics with abundant cyanobacterial mucilage in areas with rich organic matter content. The chert exhibits a gradation of colors and textural patterns, ranging from black cherts with amber/brown colorations to light cryptocrystalline matrix, highly altered-brown cherts, and brownish-yellow organic-rich cherts. In addition to quartz, fibrous chalcedony of varying sizes in empty voids is common. Associated impurities such as pyrite, galena and hematite are also present in this chert. New cartographic and geochemical data, and results from the homogenization temperatures (<156 ° C), and from Fe_2O_3/TiO_2 vs. MnO/TiO_2, and Al-Fe-Mn genetic diagrams, as well as the relatively rich content of Ba, Zn, V and Cu, strongly suggest that preserved biota was constantly bathed by silica pulses as a consequence of intermittent hydrothermal activity. The taphonomic processes leading to terrestrial permineralization and probable environments are discussed.

Uplift and exhumation in the Tianshan, western China: New insights from detrital zircon morphology and thermochronology

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The Tianshan in western China is rich in ore resources, but its tectonic uplift history related to the resource exploration is still controversial. This study provides a new strategy to uncover the tectonic uplift processes in Tianshan by combining the morphological characteristics and thermochronological ages of detrital zircons in the Tarim Basin. The morphology of the Meso-Cenozoic detrital zircons in the Tarim Basin, is dominated by three types of P, S, and G, and their average alkaline index and temperature index are 668.0−677.2 and 347.6−413.5, respectively. Moreover, the U-Pb ages of these detrital zircons are primarily divided into two groups of 270−330 and 380−470 Ma. These features indicate that the Early Carboniferous-Early Permian and Middle Ordovician-Middle Devonian alkaline granites distributed in the South Tianshan and southern Central Tianshan were the main source regions of the detrital zircons in the Kuqa Foreland Basin. The decomposition of the detrital zircon fission track ages further reveals that the provenances of the Kuqa Foreland Basin primarily consisted of the southern Central Tianshan, the eastern South Tianshan, and the central South Tianshan during Meso-Cenozoic. Among them, the eastern South Tianshan played a dominant role in the material supply. The synthesis of the decomposed ZFT ages and the lag-time evolution pattern indicated that the South Tianshan and the southern Central Tianshan mainly experienced five stages of tectonic uplifting occurred in the Devonian, the Permian, the Middle Triassic-Middle Jurassic, the Cretaceous, and since the Miocene, respectively. They were related to the subduction of the South Tianshan Ocean northward to the bottom of the Central Tianshan, the compression and accretion after the closure of the South Tianshan Ocean, and a series of collisions between the Qiangtang-Lassa-India plates and the southern margin of the Eurasia plate in the Meso-Cenozoic, respectively.

Provenance analysis of the Cenozoic succession of the Kutch Basin, western India

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The Deccan Flood Basalts cover majority of the surface exposures in the western India. However, the Kutch Basin preserves Cenozoic sedimentary rocks overlying these basalts. These rocks capture nearly 60 million years of the geological history of the basin and its surrounding areas from Paleocene to Pliocene. Most of the Cenozoic siliciclastic succession in the Kutch Basin belongs to the Oligocene and Miocene. This study reports differences in provenance within this succession based on heavy mineral assemblages and zircon U-Pb ages. The sandstone older than Middle Miocene indicate largely similar heavy-mineral assemblage comprising of tourmaline, rutile (and other TiO_2 polymorphs), staurolite, zircon, andalusite, kyanite and garnet etc., in decreasing order of abundance. The zircon U-Pb ages for these rocks indicate dominance of sediment input from source rocks ranging in age from 500 to 3600 Ma. The sandstone of Middle to Upper Miocene exhibit a dominance of epidote, titanite, apatite and garnet. The U-Pb ages of zircon in this sandstone exhibit a dominant input from source rocks younger than 100 Ma along with the older ages (500–3600 Ma). Most of the older zircon U-Pb ages revealed in this study are similar to those reported earlier from the Mesozoic succession of this basin and can be traced to the possible source areas north and north-east of the basin. The recently reported ages equivalent to the Pan-African (500–650 Ma) and Bhimphedian (400–500 Ma) orogenies may have been recycled from the Mesozoic succession. However, the zircon U-Pb ages younger than 100 Ma are likely to be derived from the rising Himalayas. The Karakoram and the Kohistan-Ladakh batholiths report similar ages. While the unconformity between Lower Miocene and Middle-Upper Miocene is reported by previous workers, the current study throws light on the heterogeneity of the Cenozoic succession before and after this unconformity.

High concentrations of microplastics hidden beneath land-detached submarine canyons

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Submarine canyons are increasingly recognized as pollution hotspots, particularly where they connect to land-supplied sediment sources, such as rivers; however, to date the processes that control the transport and burial of microplastics in land-detached submarine canyons such as the Whittard Canyon remain largely unknown. Recent studies have shown that this canyon is extremely dynamic; affected by both vigorous internal tides and even more powerful, sub-annual turbidity currents. Microplastics of different sizes, shapes and polymer types were found in turbidity currents (from a sediment trap) and their deposits (from seafloor samples), demonstrating, for the first time at a field scale, that turbidity currents carry microplastics from shelf to deep sea. Microplastics originated from both land-derived and marine-derived sources, and then were transported into the deeper canyon by turbidity currents, and finally were partly redistributed by internal tides across the canyon. We therefore conclude that the deposition of microplastics in land-detached submarine canyons is dominated by the interplay of turbidity and tidal-driven currents. We also show the highest microplastic concentration ever recorded in submarine canyons, suggesting that land-detached canyons are globally important conveyors of anthropogenic pollution.

Source to sink sediment flux of late Cenozoic northern shelf margin, South China Sea

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More than four km-thick shelf prisms were generated along Yinggehai (YGH) and Qiongdongnan (QDN) Basins in the northern South China Sea during the late Eocene (37-0 Ma). Laterally, from northwest to southeast, the overall shelf margin geometry represents an oblique pattern from YGH to QDN basin, with a remarkable change from wide shelves in the junction between the YGHB and QDNB (>150 km) in the west, to sigmoidal, strongly progradational and aggradational in the middle (connection zone between two basins), then to weakly progradational and narrow shelf (∼ 60 km) in the east of the QDN Basin margin. The estimated total sediment flux onto the margin dramatically declined from source to sink while moving away from the Red River depocenter (>12 km thickness) and dispersed along the pathway to be unloaded in the receptacles.
The zircon age distributions display multiple stacking cycles in the vertical evolution, accompanied by corresponding fluctuations in global sea level. Especially in the decreased zircon trends during the Yacheng Formation, Sanya Formation, and Huangliu Formation, corresponding to falling sea levels at 34 Ma, 21 Ma, and 8.2 Ma respectively. Additionally, the vertical sediment accumulation rate increased significantly across the entire YGH and QDN Basin margin system after 2-4 Ma, with a marked increase in mud content likely caused by long-distance, alongshore currents with high mud content during the Pleistocene.
Different from other South Asian shelf margins (e.g., Gulf of Thailand, Pearl River, Indus River, Mekong River, Irrawaddy River, and Bengal Fan), which have the sedimentation rate peak during middle-late Miocene (15-5 Ma), the Red River-YGH-QDN depositional systems reached their peak in Pliocene-Pleistocene (4-2 Ma). The overall increased sediment flux during the late Cenozoic shelf margin growth responded to high-frequency climate cycles characterized by a declining global sea level and gradual cooling temperatures in the icehouse period.

Global Carbon Cycling and Marine Anoxia during the Late Paleozoic Ice Age

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Marine anoxic events are typically associated with major perturbation to the global carbon cycle, particularly during past greenhouse periods, suggesting marine anoxia is more prone to warm or hyperthermal conditions due to low oxygen solubility and sluggish thermocline circulation. How components of Earth system, particularly the marine redox landscapes, respond to global carbon cycle perturbations during icehouse climate conditions remains rarely studied. The Late Paleozoic Ice Age (LPIA; 360–260 Ma) is the thus far longest-lived icehouse climate since the appearance of advanced plants and a complex terrestrial ecosystem, and is featured by dynamic global carbon cycling. Here I show two cases of carbon cycle perturbations during the LPIA, characterized by a large positive $\delta 13C$ excursion during the earliest Carboniferous and a dramatic negative $\delta 13C$ excursion at the close of the Carboniferous. Both events are accompanied with significant marine anoxia, but attributed to various processes and feedbacks that are potentially unique in the icehouse climate state.

Three dimensional simulation of hydraulic fracture propagation based on reservoir heterogeneity

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Tight sandstone reservoirs typically exhibit characteristics such as low porosity and low permeability, which require extensive reservoir reconstruction for the development of oil and gas resources. Generally, hydraulic fracturing is employed through horizontal wells to generate high-conductivity fractures that increase the flow area and establish communication with high-yield dessert areas, aiming to achieve efficient production. The extension and propagation behavior of fractures during hydraulic fracturing operations significantly impact the effectiveness of production enhancement. In order to accurately simulate the expansion of hydraulic fractures in heterogeneous reservoirs, this study comprehensively considers the influences of geological factors, brittleness index, rock mechanical properties, and construction parameters on the propagation path of fractures. In this paper, UFM is utilized to simulate the three-dimensional propagation of multiple fractures in horizontal wells, employing a fully coupled numerical method that fully accounts for reservoir heterogeneity, stress anisotropy, and stress shadow effects, in order to capture complex fracture network morphologies. This approach not only models fracture propagation mechanisms and proppant transportation processes, but also effectively simulates the interaction between hydraulic fractures and natural fractures. The research results demonstrate that in the J58 well area of the northern Ordos Basin, hydraulic fractures in the tight sandstone reservoirs are primarily characterized by rectangular and elliptical shapes, with the thickness of interlayers, brittleness index, and horizontal stress difference between layers being the main controlling factors for fracture morphology and propagation scale.

Significant Human Modification of the Lower Arkansas River Sediment Budget

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Anthropogenic stressors on large rivers have significantly modified riverine sediment transport. However, the impacts of dredging and sand and gravel (S&G) mining are poorly monitored. We quantify these impacts on the Lower Arkansas River (LAR), U.S.A., where anthropogenic processes are well documented. The construction of dams caused a 98% reduction in suspended sediment discharge (Qss). Since dam construction, fluvially-transported suspended sediment (4.4 ± 0.5 Mtyr-1) and suspended sand discharge (Qsand) (1.1 ± 0.1 Mtyr-1) are of the same order as the dredging rate (1.2 ± 0.1 Mtyr-1) and S&G mining rate (1.7 ± 0.1 Mtyr-1). While the modern sediment deficit on the Arkansas River is smaller than in rivers documented in developing countries, dredging and mining significantly alter the sediment balance in this large river, indicating that extraction management is needed worldwide, especially in developing economies, to improve ecosystem sustainability in large rivers.

Carbonate-hosted manganese deposits and ocean anoxia

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Many marine Mn deposits are primarily composed of rhodochrosite, kutnohorite, and Mn-calcite. These Mn carbonates are traditionally interpreted to form through the diagenetic reduction of depositional Mn-oxides, which are suggested to reflect bottom water oxygenation. In this study, Late Devonian, Early Carboniferous, and Early Triassic manganese deposits in the South China Block support an emerging view that some Mn carbonates form through direct synsedimentary (authigenic) precipitation. These Mn carbonates accumulated on distal shelves and are interbedded with lime mudstone and heterozoan carbonates that accumulated in coastal upwelling environments. Lithofacies, Ce anomalies combined with vanadium, uranium, and molybdenum enrichments indicate that the Mn carbonates were precipitated under anoxic conditions. Mn calcite encases dolomite rhombs, indicating heterogenous nucleation, which is supported by similar lattice parameters of both minerals with a small lattice mismatch. The presence of individual and aggregated rhombs, the non-stoichiometric compositions, and characteristic organic matter Raman spectroscopy peaks in the dolomite nuclei suggest an organogenic origin. Organogenic dolomite precipitation is interpreted to have preconditioned the sediment with nucleation sites for the subsequent precipitation of Mn carbonates in the shallow seafloor. Geochemical and sedimentologic evidence suggests that coastal upwelling delivered manganous anoxic deep waters to the shelves. Slightly positive Eu anomalies and decoupling of Fe and Mn imply long-range transport of hydrothermal Mn, indicating the regional deep oceans at the time must have been anoxic, as Mn2+ would be easily oxidized to insoluble Mn-oxides under oxygen-rich conditions, preventing its long-distance transport. This depositional model implies these Mn deposits record at least transient regional deep-ocean oxygen depletion in the generally well-oxygenated Late Paleozoic and Early Triassic oceans. The periodic Mn deposits are broadly coeval with the anoxia-related Hangenberg, Serpukhovian, and Permian-Triassic biotic crises. As such, these Mn deposits may be a novel product of the conditions that drove these extinction events.

Negative Carbon Isotope Excursions (CIEs) in the Early Jurassic: Lacustrine Perspective on Paleoclimate Effects and Possible Mechanisms

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This study scrutinizes the Early Jurassic Carbon Isotope Excursions (CIEs) as archived in terrestrial records, correlating them with marine sections, worldwide climate changes and speculates potential causative mechanisms through a comprehensive analysis of the lacustrine sedimentary sequence from the Da'anzhai Member of the Sichuan Basin. Detailed stratigraphic analysis and sampling, followed by a variety of geochemical and isotopic techniques applied to well RA1, have revealed significant variations in organic matter abundance, transitions in depositional environments, and three notable negative CIEs. The amplitude of negative carbon isotope shifts within the "carbon pool" during the CIEs was determined. By comparison with other lacustrine and marine profiles, these CIEs are interpreted as terrestrial responses to the Pliensbachian-Toarcian Boundary Event and the Toarcian Oceanic Anoxic Event. Biogenic isotope data indicate that the lake water underwent considerable temperature alterations, which aligned with the concurrent seawater temperature pattern, signaling global climatic changes controlled by CIEs. Furthermore, the lake sediments record mercury anomalies associated with these CIEs, indicating that massive volcanic eruptions releasing greenhouse gases were likely the primary mechanism for global carbon cycle perturbations and consequent climate warming. The study delineates the response characteristics of Da'anzhai Lake to Early Jurassic CIEs, offering valuable evidence for global correlations and potential mechanisms behind these events. It underscores the synergistic role of terrestrial and marine ecosystems during major environmental disruptions and their collective response to global climate change.

Fluvial to marine transition within the Late Cretaceous Mahadek Formation, southern Shillong Plateau, NE India- Implications of Late Cretaceous sea-level rise in response to tectonics

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Rising sea level induced by tectonic unrest leads to spatial variations in depositional environments and paleogeography. The Late Cretaceous Mahadek Formation, Khasi Group, southern Shillong Plateau uniquely portrays this variation due to the effect of relative sea-level rise within an intracratonic basin in response to the formation of several grabens/half-graben topography. The lower part of the formation is dominated by a fluvial system, initially confined to a gravelly river network to a sand-dominated, braided channel followed by a meandering system characterized by abandoned channels, overbank fines, point bars, and crevasse splay deposits. As the sea level rises, the fluvial system gradually changes into a marine system. Detailed state-of-the-art facies analysis shows that marine encroachment from the south–southwest initiates the deposition of the upper part of the Mahadek Formation. However, the nature and extent of the marine system vary spatially. (i) A tide-dominated environment developed directly overlying the Precambrian basement in the northern part of the basin as depicted by herringbone cross-strata, the presence of mud drapes between cross-strata, reactivation surfaces and changes in cross-strata geometry. (ii) A barrier bar-marsh set up in the southern part of the basin; and (iii) a wave-dominated open shelf condition was developed during intense marine encroachments in southwestern part as depicted by the presence of hummocky cross-stratification, wave ripples, wave-winnowed lag deposits and occurrence of marine invertebrate fossils. This study highlights the transition from a fluvial to marine environment vis. a vis relative sea-level rise and basin subsidence.

Effects of the establishment of modern forests on ancient ocean life

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The Devonian period saw an increase in terrestrial organic matter abundance through the establishment of tree root networks and forest diversification. The development and deepening of root networks from the Emsian-Eifelian (407-387 Ma) into the Givetian and Frasnian (387-372 Ma) resulted in increased pedogenesis and weathering that would have likely affected the marine realm. Several positive $\delta^{13}C(org)$ excursions are recognized in Frasnian strata worldwide and in this study (up to +4.3‰) of marine shales and a well-preserved carbonate platform in the Western Canada Sedimentary Basin (WCSB). The positive excursions are referred to collectively as the punctata Event, named for the corresponding conodont zone. A possible cause of these excursions has been linked to forest diversification taking place at this time. Trace metal proxies and longwave infrared spectral imaging of concentrated intervals of amorphous silica (possibly radiolarians) suggest that increased soil weathering likely resulted in upper water column productivity, and bottom water anoxia. What is not well understood is the effect that suspected increased nutrient levels and siltation had on major reef builders, such as stromatoporoids and corals. This study investigates the potential link between the punctata Event and changes in reef-building biota in the Redwater Leduc Formation reef. Changes to reef-building organisms have been observed in the middle to upper Leduc Formation reefs where textures shift from a stromatoporoid framestone, to stromatoporoid-renalcis framestone, and finally to a coral-dominated framestone. Several megalodon bivalves, considered to possibly be resistant to increased nutrients, have also been recorded at a consistent interval across preserved Leduc Formation platforms. The findings of this study aid in developing our understanding of the controls on reef-building organisms and the effects of significant changes in the terrestrial environment on marine ecosystems.

Swimming trunks: Distribution of plant-sediment interactions in the late Palaeozoic

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Vascular plants exert significant biogeomorphic influence on terrestrial landscapes through controls on substrate stability, sediment accumulation and hydrodynamics. The near-synchronous stratigraphic correlation of sedimentary evidence for geomorphic diversification of fluvial environments with fossil evidence for the expansion of Palaeozoic vegetation attests to the importance of this influence in deep time. Many sedimentary facies (and, by extension, landforms) do not exist until certain milestones of plant evolution are passed. On the smallest spatial scale, discernible at outcrop, vegetation-induced sedimentary structures (VISS) provide tangible evidence of plants mediating sediment deposition and erosion in ancient environments, because they represent primary sedimentary structures formed from in situ plant-sediment or plant-hydrodynamic interactions. Yet, despite the ubiquity of VISS in modern river systems and their capacity to represent volumetrically significant accumulations of sediment, descriptions from the geological record remain sporadic. In this talk we highlight the importance of VISS by highlighting several newly discovered examples of VISS and other vegetation-dependent sedimentary structures dating to a crucial interval of plant evolutionary reorganization. Pennsylvanian and Early Permian strata record major changes in climate and plant assemblages, from lycopsid-dominated tropical 'coal swamps' to conifer-dominated dryland environments: the so-called 'Carboniferous rainforest collapse'. VISS from pre-'collapse' strata are typically found in association with abundant in situ plants, preserved in coal swamp environments. In later oxidising red-bed facies, where taphonomic conditions encouraged plant decay, vegetation falsely appears less abundant. By identifying VISS geometries in the older facies, we have been able to identify similar examples in younger strata where plant remains are absent, and successfully used these sedimentological signatures to prospect for new fossil occurrences. The VISS we have identified in latest Carboniferous and Permian strata demonstrate that plants such as early conifers persisted as fundamentally important sculptors of sedimentation and erosion, even after the demise of the coal forests.

Interglacial eolian dust, ocean fertilization, and Neoproterozoic Earth oxygenation

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Feedback processes that drove Earth's second major stepwise increase in ocean-atmosphere oxygen levels during the Neoproterozoic are poorly constrained. Purported nutrient transport to the ocean via rivers and coastal upwelling seem insufficient to fuel the surface ocean primary productivities required to produce the observed rise in oxygen concentrations. Recent correlation of interglacial siltstone successions in paleogeographic context suggests that bioessential elements contained in copious wind-blown dust from the horse latitudes was instead critical for fertilizing the late Precambrian oceans. It is hypothesized that dust accumulation was concentrated in arid, high-pressure latitudinal belts that develop at 30° N and S. The rapid dispersal and deposition of windblown dust is thought to also explain the steep increase in global radiogenic Sr isotope values ($^{87}Sr/^{86}Sr$) in post-Sturtian to early Cambrian strata. The windblown silt and clay were also likely an important source of nutrients for an evolving biological pump that increased global primary production and accelerated the rate of organic matter and pyrite burial. An eolian source could also account for the nutrient deficit in models that rely primarily on riverine delivery of P and Fe, for example, for stimulating photosynthetic oxygen production in the Neoproterozoic. Constant erosion of landscapes by wind likely promoted enhanced CO_2 uptake due to silicate weathering because it continuously exposed mineralogically immature glacial rock flour to the atmosphere. Furthermore, the sequestering of atmospheric CO_2 recorded in organic-rich siltstone, correlative hydrocarbon source rocks, and graphite deposits, is interpreted to have been an important negative feedback process, which prevented runaway greenhouse conditions during interglacial periods between snowball glaciations. The oxygen produced by this eolian marine biological pump (EMBP) is thought to have helped pave the way for the appearance of the first multicellular animals and oxidized seawater methane to generate the Shuram Carbon Isotope Excursion.

Multi-Wave Seismic Sedimentology Study in Characterization of Channel Sand, Example from Middle Jurassic Shaximiao Formation, Sichuan Basin, China

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Shaximiao Formation in the Northwestern Sichuan Basin belongs to delta front submerged diversion channel sedimentation. Drilled wells have proved that multi-period sand-bodies stacked vertically and have significant lateral non-homogeneity. Sand-bodies in different channel location are apparently different in porosity, which results in complex longitudinal wave (PP-wave) seismic responses at the interface between surrounding mudstones. To accurately characterize the channels, this study proposes a multi-wave joint seismic prediction technique, combing both transversed wave(PS-wave) seismic data and the pre-stack PP-wave seismic data. The results of the study show that: 1. The longitudinal impedance of sandstone decreases with the growth of porosity and sandstones with 6%-8% porosity have no tangible longitudinal impedance difference with the surrounding mudstone. Hence, the PP-wave seismic response of the sandstone top interface varies from peak to weak amplitude and finally trough as the sandstone itself varies from tight to highly porous(2% to 12% porosity). 2. Regardless of the variation in porosity, sandstone always have a higher transverse wave impedance than the mudstone. Consequently, sandstone top interface stably refers to a peak reflection in PS-wave seismic profile. 3. Phase shift -90° of the PS-wave seismic could increase vertical resolution and separate stacked sand-bodies whose seismic response are overlapped in original profile. 4. The P-G attribute of PP-wave pre-stack seismic gathers could reflect the transverse wave impedance changing rates and it performs pretty much close to the original PS-wave seismic. Thus, it could be used as an alternative way in areas without PS-wave seismic data. In summary, the utilization of both PS-wave and pre-stack PP-wave seismic data could characterize channel sand-bodies without its non-homogeneity in the study area. The technique has been applied in well displacement in Zitong gas field, Northwestern Sichuan Basin, and shows great effect.

Sedimentological and pore-scale characterisation of Bockfließ Fm, Vienna Basin, Austria: implications for caprock integrity

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The Early Eocene Bockfließ Formation in the Vienna Basin represents a phase of lacustrine to brackish-littoral sedimentation. The fine-grained sediment of this formation aided in this formation being a regional caprock. As part of this study, several historical subsurface cores and drill cuttings, collected as part of classic E&P projects, were subjected to a number of appropriate analytical techniques for a detailed and holistic characterisation of the formation. These analytical techniques include core descriptions, petrography, XRD, MICP and 'scratch testing'. The analyses resulted in data covering sedimentological, structural, petrophysical and geomechanical aspects of the formation. The results from the sedimentological analyses provided information on depositional systems, formation geometry and heterogeneity. The cores and cuttings data also shed light on the structural/tectonic impact. MICP-derived data such as maximum fluid column height and permeability were examined with respect to lithofacies in its depositional context. Rock fabric analysed under microscope highlighted the impact of sedimentary structures, bioturbation and cementation. Mineralogical data provided insights how composition (sand/clay/carbonate content) governs caprock integrity, which can be directly compared to rock strength obtained through scratch testing.

Salinity indicators in sediment through the fluvial-to-marine transition (Fraser River, Canada)

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The transition from non-marine to marine conditions along rivers (fluvio-tidal transition) is characterized by the interaction of salt- and freshwater and fluvial and tidal currents. Determining the salinity of water under which sediment is deposited through the fluvio-tidal transition has been attempted using a wide range of sediment- and geochemical proxies with varying degrees of success. Herein, six proxies (Sr/Ba-HAc, Sr/Ba-NH_4Ac, $\delta^{13}C$, C/N, and the relative abundances and concentrations of dinoflagellate cysts) are compared from the Fraser River Delta, Canada and surrounding coastal areas. Proxies are compared by depositional position along the fluvio-tidal transition, by salinity, and by sedimentological characteristics. Most proxies exhibit distinct trends between parts of the river that experience sustained marine water (saltwater) influence over seasonal and tidal timeframes, and parts that experience only freshwater or periodic saltwater influence. No attributes are reliable indicators of depositional position where saltwater incursion is short lived or where water is fresh. Where marine influence is sustained, Sr/Ba-HAc and Sr/Ba-NH_4Ac are the most reliable positional indicators along the fluvio-tidal transition. When compared strictly to salinity, Sr/Ba-HAc, Sr/Ba-NH_4Ac, and $\delta^{13}C$ all correlate predictably except in delta front and prodelta settings. Our data show that all six sediment attributes are heavily impacted by river-derived sedimentation, and it is not appropriate to compare values from strongly river-influenced settings (e.g., deltas) with those from weakly river-influenced settings (e.g., bays and estuaries).

Using biological sedimentary structures to estimate stratigraphic time preserved at outcrop

Prof Neil Davies[1], James Craig[1], Yorick Veenma[1], Hamilton Allport[1], William McMahon[1]
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At outcrop, many packages of siliciclastic sedimentary rock have the potential to archive patches of synoptic topography - truly chronostratigraphic surfaces, which were once geomorphic surfaces at the interface of sediment and water/air. Such patches imply that sedimentary rock outcrops have the potential to archive short timescales, within strata of great antiquity that are frequently supposed to have been deposited over very long time intervals. Yet while such examples demonstrate that bedding surfaces may record short durations, it is often harder to ascertain the timescales over which packages of sediment accrued. In this talk we give several examples of interactions between organisms that colonized bedding surfaces and the sediment that subsequently accrued on them. Cambrian to Permian aged examples of burrows, standing trees and sessile marine fauna, from different sedimentary environments, permit the accrual rate of sediment packages to be estimated to be within the lifetime of certain organisms. Extrapolating this ‘biological time’ yardstick to estimate accrual in similar outcrops where such colonization evidence is lacking implies that many siliciclastic sedimentary outcrops could have accrued very rapidly. This understanding, that the most accessible building blocks of the sedimentary record (outcrops) record short intervals of time, has implications for interpreting the meaning of many of the signatures they host, as well as for our understanding of the sedimentary record as an archive of Earth history.

Britain's oldest microfossils (?): new examples from 1.2 billion year old limestones of Northern Scotland

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The Proterozoic Stoer Group is a 1.2 Ga sequence of mostly clastic red-beds of predominantly fluvial origin, which lies unconformably upon an ancient land surface developed on the 2.8 Ga Lewisian Gneiss in NW Scotland.

Within the basal part of the succession, close to the underlying basement gneiss, lies a thin sequence of limestone-mudstone laminites of disputed origin. These rocks have variously been interpreted as microbial stromatolites, inorganic chemical crusts, deep burial diagenetic precipitates and re-worked Palaeoproterozoic limestones.

A combination of new and unpublished legacy data, including field and petrographic observations, Qemscan mineralogy, oxygen isotope analysis and palynological analyses strongly supports the original interpretation of a microbial origin for these limestones and has recovered remains of organic microfossils.

Morphological comparison of structures within the limestones, including small tabular clasts, thin calcite "crusts" and sub-spherical, globular mounds, shows striking similarities with the macromorphology found in modern, cold-water microbial carbonates and ancient Cambro-Ordovician stromatolites from the North of Scotland.

The limestones also host a suite of enigmatic structures with the appearance of fracture fills or injection features, apparently locally displaced, intraclastic blocks, and outsized gneiss clasts up to large cobble size. Interpretation of the origin of these features is critical to the understanding of the depositional setting in which the limestones formed.

Results from new palynological analysis, using both acid digestion and thin sections, shows the presence of organic-walled microfossils. These include examples of Lophospheridium sp., Leiosphaeridia sp. and other leiosperes, which have never previously been recorded from this locality. This makes them among the oldest, possibly the oldest, microfossils ever found in the UK. Other organic remains, including possible cellular clusters, are yet to be identified, but may prove to be even more important.

Exploring emplacement mechanisms of hyaloclastite beds: the Aci Castello case study

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Water/lava interactions represent the fundamental mechanism triggering the emplacement of pyroclastic layers in many non-explosive volcanic contexts. Once a magmatic melt outflows onto the surface, in fact, it can mix with the cold seawater and undergo fragmentation, generating hot currents of pyroclastic particles. Deposits emplaced in such conditions are known as hyaloclastites and are normally observed in submarine contexts. Understanding emplacement mechanisms, architectures and microscopic features of these deposits are crucial to develop models on their emplacement and assessing their impact on the environment.

Therefore, this work explores the evolution of an effusive-explosive complex in Aci Castello, accumulated by the outflow of basaltic melts during the first stage of construction of the Etna volcano. Combining fieldwork, petrographic analyses and 3D model rendering through a GIS, it proposes a 3D reconstruction of volcano-sedimentary architectures where two facies are combined together in a fan-like body. Effusive facies includes pillow basalts, whereas explosive facies includes hyaloclastic beds with basaltic fragments and muddy rip-up clasts in a reddish groundmass. Petrographic analyses identified microtextures featuring both effusive and explosive deposits, with pillow basalts showing a microcrystalline dark brown groundmass wrapping phenocrystals of plagioclase and pyroxene, and hyaloclastites with loose crystals and basaltic fragments in a yellow, glassy, vesiculated groundmass. Muddy rip-up clasts are commonly composed of carbonate and clay minerals. 3D rendering shows the interdigitations of basaltic and hyaloclastic layers in a prograding fan-like body. Such preliminary results indicate an intimate correlation between magma ascent and outflow rate and the development of either the effusive or explosive facies. Microscopical analyses on the latter suggest that magma fragmentation produces particles that are still hot once emplaced, physical condition that favors their sinterization as glassy-supported volcaniclastic deposit.

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Salt Movement During Minibasin Development has Minimal Influence on Fluvial Facies Distributions in the Triassic of the Central North Sea

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Salt mobilization during sediment deposition can result in a complex relationship between the timing and location of accommodation space generation and sedimentation in salt minibasins and/or the erosion and connectedness of sediment drainage systems across intervening salt highs. In many examples of sedimentation during active halokinesis, adjacent minibasins may be isolated from each other and can capture and/or focus drainage, often developing a 'fill-and-spill' type relationship. In these examples, salt movement strongly influences facies distribution. Channels are commonly restricted to topographic lows which may be immediately adjacent to salt bodies, and fine-grained sedimentation dominates on intervening topographic highs that develop above salt bodies. Here we document an example from the Triassic of the Central North Sea (CNS) where fluvial facies distributions were not influenced by salt movement during deposition despite ongoing halokinesis.

In the CNS, it is established that late Permian Zechstein salt was remobilized during the early Triassic resulting in the development of a series of minibasins. Salt movement strongly influenced thickness variations within the early Triassic succession with up to 2500 m of sediment deposited in minibasins. Early Triassic deposition on salt highs is poorly constrained due to a lack of seismic resolution, limited well data and post-Triassic erosion, however where information is available from wells, a thin Smith Bank Formation is present. Similarly, in the mid-to-late Triassic although aggradation continued in minibasins, sedimentation occurred on salt highs with well-developed channel belts present. Importantly, throughout the Triassic, sedimentation occurred both within minibasins and on salt highs such that salt structures were never exposed at the surface and that the depositional surface was flat. In summary, salt movement influenced sediment accumulation but not facies distribution.

Origin of dolomite in lacustrine organic-rich shale: A case study in Shahejie Formation of Dongying Sag, Bohai Bay Basin

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The distribution of dolomite with different types and crystal sizes is widespread in most organic-rich shale reservoirs; however, the characteristics and formation mechanism of dolomites in these shales are still poorly understood. In this study, petrographic and geochemical analyses were conducted to interpret the formation of dolomite in lacustrine organic-rich shale from the Shahejie Formation in the Dongying Sag, Bohai Bay Basin. Four types of dolomites, which represents episodic recrystallization, were classified based on the crystal size and shape: (1) micritic dolomite (Dol-1), (2) sub-to euhedral (cloudy cores with clear rims) dolomite (planar-e) (Dol-2), (3) anhedral dolomite (coarse planar-s to non-planar crystals) in phosphatic particles (Dol-3), and (4) fracture-filling anhedral dolomite (Dol-4). The Dol-1 has non-planar mosaic micritic grain-size crystals with irregular intercrystalline boundaries and dull CL, suggesting the dolomitization during the early burial stage. It tends to occur in high paleosalinity and warm conditions.

Furthermore, the syngenetic relationship with plenty of framboidal pyrite and gypsum suggests that BSR may influence the formation of Dol-1. The high content of Sr and low content of Mn/Sr also indicate less influence on burial. The Dol-2 crystals show cloudy cores with clear rims attributed to progressive dolomitization during burial. It is always associated with the organic matter within the organic-matter-rich lamina. The anhedral crystals and undulate (sweeping) extinction of Dol-3, usually encased by phosphatic particles in the organic-rich lamina, reflect the recrystallization affected by bacteria and subsequent the thermal evolution of organic matter. The Dol-4 fulfil the abnormal pressure fractures crosscutting through the earlier phases (Dol-1 and Dol-2) with undulate (sweeping) extinction and different REE patterns. It may be affected by hydrothermal fluid, which is influenced by the thermal evolution of organic matters.

DISTRIBUTION PATTERNS AND IMPACT OF SILICIFICATION ON RESERVOIR QUALITY OF LACUSTRINE PRE-SALT CARBONATES FROM SANTOS BASIN, BRAZIL

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Diagenetic silicification processes deeply impact the quality is one of the important Barra Velha Formation reservoirs, Pre-salt section of the Santos Basin. Different silica varieties are related to distinct processes, which can be used to constrain the timing and origin of the precipitating fluid, as well as their potential distribution. Here we report results from a detailed petrographic study, associated with petrophysical and fluid inclusion analyses of an intensely silicified 70 m cored interval, seeking to understand the distribution and impact of silicification. The lower interval of the studied core is intensely silicified, commonly brecciated, and with an unrecognizable primary texture. Fibro-radial chalcedony, drusiform and coarsely-crystalline quartz surround, and fill large vugular and channel pores. The middle interval is composed of predominantly reworked rocks with moderate silicification. Microcrystalline quartz commonly replaces carbonate constituents and the original matrix, while coarsely-crystalline quartz and fibrous chalcedony fill interstitial spaces, vugular and fracture pores. The upper interval corresponds to predominantly reworked rocks that were less silicified. There, silicification is rare and occurs mainly as microcrystalline quartz and chalcedony replacing intraclasts and less commonly in situ calcite spherulites and shrubs. The silicification of intraclasts was generally scattered and heterogeneous, though locally forming intensely replaced levels. Fluid inclusion microthermometry in representative samples of each core interval showed that early coarsely-crystalline quartz cement precipitated at <50 °C with salinity of 21-15 wt.% (evaporitic influence). A second fluid percolation event at 73 °C with a salinity of 18-8 wt.% (evaporitic to magmatic influenced) was found at the base of the core. Our data suggests that silicification is mostly represented by early diagenetic, replacive microcrystalline quartz, though a late-stage mixed hydrothermal-mesodiagenetic silicification event also impacted the rocks.

Drones and geospatial technologies in high schools: How to recruit the next generation of sedimentologists

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Unmanned Aerial Vehicles (UAVs), are increasingly used in STEM research and educational purposes as they are a cost-effective and time-efficient way to gather geospatial data, and they are a fantastic way to engage students. UAVs are utilised to survey the landscape, especially in locations where students are unable to access due to logistical or OHS reasons (even Mars!). They are also useful for students to better understand abstract concepts and to aid in conceptualisation of the 'bigger picture', allowing students to 'see science for themselves'.

UAVs are a powerful educational tool if repeated missions are conducted on dynamic natural systems, such as mangrove and salt marsh systems, fluvial environments and coastal environments since they capture both macro and micro changes in physical landscapes and ecosystems. This provides insights into the spatial and temporal evolution of the environment, and can be used to inform future management decisions. The output images, videos and surveys can be annotated and utilised as geospatial base maps for fieldwork activities. Student engagement and critical thinking skills can be enhanced by allowing the students to use the outputs pre-excursion in order to identify accessibility of field sites and possible sites for investigation.

James has been utilising UAVs for eight years for a diverse range of educational purposes such as geophysical and climate change hazard identification (Hawaii, Italy, UK and Australia), geomorphological evolution of fluvial systems (New Zealand), changes in coastal landforms (Australia), ecosystem mapping (Australia), and production of geospatial base maps for STEM-focused fieldwork (UK, Hawaii, New Zealand and Australia). He will offer case studies and insights in how UAVs can be used to increase both visibility and purpose of geoscience in high schools, and thus excite our next generation of sedimentologists.

Aptian-Albian opening of the Equatorial Atlantic Gateway: new evidence from Early Cretaceous sediment waves and contourite drifts west of the Guinea Plateau

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Plate tectonics have had a significant impact on the opening and closing of ocean gateways, which in turn have influenced global climate and ocean circulation throughout the history of Earth. The mid-Cretaceous opening of the Equatorial Atlantic Gateway (EAG) resulted in a major reorganization of global ocean circulation, impacting on global climate, marine biotic evolution, and deep-ocean oxygenation. The EAG opening took place in several stages, along the oblique rift and transform margins of Africa and South America, linking the North and South Atlantic Oceans. Despite its importance, the EAG's temporal and spatial evolution remain poorly constrained, particularly the onset and intensification of deep-water mass exchange via the gateway. In this study, we aim to i) establish a seismic stratigraphic framework for the Guinea-Bissau margin, ii) describe bottom-current features and iii) develop an updated model of the opening and deepening of the Equatorial Atlantic Gateway during the Early to Late Cretaceous.
Detailed seismostratigraphic interpretation of the dataset revealed several morphosedimentary features indicating changes in deep-water circulation: i) small-scale sediment waves (< 1.5 km-wide), topped by a regional unconformity of middle to late Aptian age (~119-115 Ma) that separates these from, ii) well-developed, up-slope migrating giant sediment waves (~5 km-wide), evolving into more aggradational geometries upward, and iii) a contourite mounded drift, eroded at the top by the Albian Unconformity (~104 Ma). Our findings suggest that the EAG opened gradually during late Aptian to Albian times, with these features indicating changes in water-mass exchange across the gateway, with a connection between the North-Central and the Equatorial Atlantic Oceans occurring as early as the Late Aptian. It emphasizes importance of understanding the spatial and temporal evolution of the EAG, highlighting the significance of comprehending past ocean gateways for predicting future large-scale climate and environmental change linked to reconfiguration of ocean current dynamics.

Diagenesis and reservoir porosity prediction in a hybrid-energy delta: example from the Upper Cambrian to Lower Ordovician Barik Formation, central Oman

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ABSTRACT
The study investigates the Upper Cambrian-Lower Ordovician Barik Formation, an outcrop in Central Oman mirroring subsurface gas reservoirs in the Interior Oman Salt Basin. Employing depositional and sequence stratigraphic analysis, it anticipates diagenetic modifications' nature and extent within a hybrid-energy delta system. This system comprises diverse depositional facies: mouth bar/shoreface, tidal flat, tidal channel, and distributary channel, constituting a highstand system tract. Petrographical and mineralogical tools like optical microscopy, scanning electron microscopy with energy dispersive spectrometer, X-ray diffraction, and stable isotopes examined the Barik Formation's constituents.
The Barik Formation comprises coarse to fine-grained siltstones and moderately sorted sandstones, mainly feldspathic to sub feldspathic arenites. Variations in reservoir porosity stem from diverse diagenetic alterations, unevenly distributed among facies associations. Eodiagenesis introduces mechanically infiltrated clays and feldspar and mica kaolinitization. Muddy water seepage through tidal pumps introduces these clays into sandstones. Despite initially impacting reservoir quality adversely, these clays later aid in preserving porosity during deep burial by obstructing quartz and feldspar cementation.
Kaolitization, prompted by meteoric water influx during highstand delta progradation, occurred. Subsequent burial led to compaction, negatively impacting porosity due to minimal initial cementation. Illitization and chloritization of the infiltrated clays limited quartz and feldspar overgrowths during burial, supporting detrital grains and preserving porosity. Feldspar dissolution and kaolinitization during burial further enhanced porosity. Eodiagenetic cement absence favored porosity reduction through compaction, while infiltrated clays aided porosity preservation during subsequent burial stages.
This study serves as a model for analogous hybrid-energy delta sandstone reservoirs, elucidating diagenetic alterations' roles in reservoir quality control. It clarifies the diagenetic alterations' types, distribution, and temporal and spatial impact on reservoir quality in deeply buried sandstones, offering valuable insights for similar reservoir systems.

Keywords: Diagenesis, Reservoir Quality, Hybrid-Energy Delta, Barik Formation, Cambrian-Ordovician, Central Oman

Reconstructing paleoenvironments through sedimentology and ichnoentomology: a case study in Lanzarote, Spain.

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Paleoclimate studies cannot be separated from sedimentological and paleontological investigations. Ichnoentomology, which analyzes the fossilized insect traces, can thus provide information on paleoenvironment related to insect activity.
Recent studies conducted on Lanzarote Island (Canary Islands, SP) highlighted the presence of diffuse insect nests (probably either of Coleoptera or Hymenoptera) related to late Pleistocene (130 to 23ka) deposits cropping out in the El Jable Plain. They are situated in the central part of the island and bordered on its eastern flank by cliffs remnant of the Famara Caldera. Deposit filling the plain are colluvial and alluvial fans merging into an alluvial plain where they interfinger with aeolian dunes.
Nests are composed of medium-grained quartz sand, have a quasi-cylindrical shape and are 2.5cm long 1cm wide. They occur as high-concentration clouds within calcrete deposits interlayered with aeolian sands and/or distributed among the finer layers between conglomerates strata of the alluvial fans.
Ancient DNA preliminary analysis allowed us to refer the nests to beetles. Absolute dating has been conducted on the Hemycicla sp occurring in the same level of the nests from two different interdune strata.
According to the derived ages (39768±601 and 27255±220 cal y BP), beetles' nests primarily formed post-40,000 years during MIS3, a “cold" interglacial punctuated by high frequency climate oscillations called Dansgard-Oeschegert (DO) events. DO9 and DO4 are the two recognized.
These events caused abrupt and fast humid/arid climate fluctuations along the Lanzarote Island.
Since beetles nested in the soft-muddy deposits following the receding stages of major floods and in between dunes when their reduced activity allowed calcrete formations, we claim that they nested El Jable plain throughout relative humid but stable phases during which no mega floods or dust storms occurred. Thus, wet climatic fluctuations may have caused a peak in the insects’ colonization of the plain.

Abnormally high-temperature wildfires during the end-Triassic mass extinction

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The end-Triassic mass extinction (ETE) (~201.58 Ma) was a critical period in the Earth's history. The rapid emplacement and eruption of the Central Atlantic Magmatic Province (CAMP) bring huge environmental pressure on the global surface ecosystem, such as the synchronous wildfire events. However, it remains debated whether the wildfires occurred on a global scale or not. Previous reports have commonly focused on the area directly influenced by the CAMP. This study collected samples across the ETE and Triassic–Jurassic boundary (TJB) in the Haojiagou section at the southern margin of the Junggar Basin, NW China. Abnormal abundance of combustive-derived polycyclic aromatic hydrocarbons (PAHs) and tridymite were found, which both demonstrate the high-temperature alteration before or after deposition. Once the factors of diageneis and local volcanisms are excluded, the evidence proves an abnormally wildfires occurring in the Haojiagou during the ETE. The anomalies well correspond with the Hg/TOC peaks, indicating the CAMP maximum. This is the first report on abnormally high-temperature wildfire records across the ETE outside the CAMP region. On basis of globally integrated stratigraphic correlations, it is concluded that the sharply rising wildfire intensity may be triggered by the CAMP effects on land far beyond a regional scale.

Mechanisms pacing the locus of organic carbon burial in the aftermath of the Toarcian hyperthermal event

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Carbon cycle-climate dynamics were nonlinear through Earth's history, driven by changes in internal and external forcing processes acting on various geological timescales. This study focuses on determining the relationship between volcanism, orbital parameters, and organic carbon burial during the Aalenian (Middle Jurassic) - a pivotal time at the dawn of the Mesozoic Marine Revolution, marked by a disruption of the carbon cycle and major climate shifts. Here, new high-resolution magnetic susceptibility and trace elements data are combined with previously published organic carbon isotopes and total organic carbon data from two sites in France and Chile. Our dataset shows for the first time a temporal coincidence between the major carbon cycle perturbation during the middle–late Aalenian and the onset of enhanced volcanic activity, suggesting a causality link. We propose that volcanic activity triggered a transient warming episode within the long-term Middle Jurassic coldhouse and played a key role in shifting organic carbon burial from the ocean to terrestrial settings. This period therefore contrasts with other Mesozoic carbon cycle perturbations, which generally record enhanced marine organic matter burial in oxygen-depleted environments during volcanism-triggered warming events.

Lithofacies and depositional settings of the Coniacian- Campanian Chalk in the Mons Basin

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This research presents an in-depth analysis of three drillholes in the Mons Basin, which yielded 350m of Coniacian to Campanian chalk cores. Detailed geological logging was conducted on the well-known local chalk formations of Trivières, Saint Vaast, and Maisières. A thorough sedimentological characterization was performed, from macrofacies to SEM microtexture. Petrographic observations and geochemical analysis indicate eogenetic calcite cementation and phosphatization in two benchmark levels, already known for their high glauconite content, namely the base of the Trivières chalk and the Maisières Formation. The upwelling currents, prevalent during the Late Cretaceous, are likely the source of phosphates, and the cause of the reduced sedimentation rate. The strong anoxic currents resulted in the formation of hardgrounds, the development of glauconite pellets and pyrite within shallow subtidal sediments. The geological logging also allowed the identification of multiple conglomeratic chalk intervals in the Trivières formation. They likely result from restricted sediment destabilization due to the local extensional tectonic activity. Moreover, the identification of deformation bands attests of the synsedimentary tectonic activity within the basin. Overall, this study unravels the various phenomena, including marine currents, sea level fluctuations, and tectonic activity, that influenced chalk deposition in the early Mons Basin chalk sea.

Exploring the geochemistry of weathering profiles, siliciclastic sediments, paleosols, and sedimentary rocks in 3D A–CN–K–FM tetrahedral space as a means to interpret provenance, chemical weathering intensity, sorting, and diagenesis

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The most widely utilized geochemical tool for interpreting chemical weathering, and by extension, paleoclimate, in silicic rocks is the chemical index of alteration (CIA), which was invented forty years ago. Since then, application of the CIA concept, a 1D calculated value, and 2D ternary diagrams based on the CIA concept has been applied to comment on geochemical, and thus mineralogical, effects related to provenance reconstruction, hydrodynamic sorting during sediment transport, and diagenesis. The original CIA concept utilizes the elements aluminum (A), calcium (C), sodium (N), potassium (K), iron (F), and magnesium (M), but either ignores (absence of FM) or groups elements (grouping CNK) in different plots despite the need to have them present or retaining their separation. Plotting data in tetrahedral space allows for the concurrent evaluation of silicate-based rocks regardless of how mafic or felsic the parent rocks are on the same diagram, while retaining feldspar differentiation and adding the important ferromagnesian component. Data plotted in A-CN-K-FM tetrahedral space demonstrate that the 1D CIA value and data arrays plotted on 2D ternary diagrams may lead to mistaken interpretations of major-element geochemical data. A critical component of working in the A–CN–K–FM tetrahedron is that geochemical trends may be placed in the context of all common rock-forming mineral compositions. We explore how data plotted in tetrahedral space improves on both 1D and 2D utilizations by showing how the data may be properly used to: (1) determine provenance, (2) shed light on the effects of hydrolysis and oxidation in weathering profiles and paleosols (and thus, paleoclimate), (3) determine the extent of sorting and compositional differentiation based on grain size during transport, and (4) leads to the identification of compositional pathways related to geochemical changes that occur during diagenesis.

Provenance analysis of Miocene siliciclastics from Northern Calabria, Italy

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Calabria, located in southern Italy, represents a tectonically highly active area, a result of subduction, thrusting, and faulting caused by Africa-Eurasia plate convergence. Northern Calabria forms part of the Calabria Massif, made up of an allochthonous segment of the western Variscan belt. This topographic high is exposed to the south of the Apennine Mesozoic to Cenozoic sedimentary nappes. All these nappe stacks have been reorganised structurally and exhumed during the Oligocene-Miocene. Using the stratigraphic record of sedimentary basins, the main exhumation phase of the northern Calabrian Massif (Sila Massif and Coastal Chain/Catena Costiera) should be characterised. The Rossano, Ciro, and Crotone sub-basins were selected, essentially representing the fore-arc basin of NW-directed subduction below the Calabrian arc. Siliciclastic samples ranging from fine-grained sand to conglomerates, spanning ~15 Myr from Aquitanian to Messinian, were collected from the basins. A multi-proxy provenance study was designed combining heavy mineral analysis (HMA) via semi-automated Raman spectroscopy, zircon U-Pb-He geochronology, and garnet geochemistry via microprobe. Integration of these methods should reveal lithology and locations of sediment sources and highlight changes throughout the stratigraphic record, both spatially and temporally. HMA results show garnet and apatite as the main heavy mineral phases for the majority of samples, conversely the ultrastable heavy mineral phases are relatively low. There is an unexpected high contribution of high-pressure metamorphic phases like lawsonite, glaucophane and kyanite, likely sourced from western regions of northern Calabria (e.g. Catena Costiera). This is more pronounced in the younger samples, but is widespread throughout. The southernmost Crotone sub-basin shows significant contrast with high proportions of epidote and andalusite. Pairing this HMA with high and low temperature geochronology data will foster our understanding about timing and mechanisms of Calabrian arc exhumation and uplift.

Sedimentological indicators of the Middle Jurassic epicontinental sea transgression on the Lower Jurassic fluvial sediments in the central part of Polish Basin

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The end of the Early Jurassic (Late Toarcian) was connected with eustatic sea level fall. Sedimentation in fluvial environment dominated at that time within the Polish Basin. Composed mainly of fluvial sandstones Borucice Formation occurs in the whole epicontinental basin of Poland. It is dominated by white color, cross-bedded, massive or with clay laminas sandstones representing river channel subenvironment and ripple-bedded sandstones or parallel laminated heteroliths deposited in river plain and crevasses subenvironments.

At the beginning of the Middle Jurassic eustatic sea level rise caused transgression of shallow epicontinental sea into the Polish Basin. It entered the area of the Polish Lowland probably from the south-east from the Tethys Oceanin at the Aalenian time. In the initial period the sea was restricted to the Mid-Polish Trough, the axial part of the basin, which extends along the Teisseyre-Tornquist Zone. It is not clear in which ammonite zone this transgression occurred, because sediments contain only Aalenian age agglutinated foraminifera. The lowest part of the Middle Jurassic succession encompass estuarine sediments. There are mainly different sandstone lithofacies with subordinate intercalations of mudstones. They are arranged in sedimentary cycles with a sharp bottom boundary and grain size usually decreasing upwards. There are also frequent cycles with no grain size change, but a gradational boundaries between various lithofacies are observed. Generally observed cycles represent two subenvironments of estuary dominated by tides:

(1) middle estuary with sediments of sand and mixed plain; subordinate with mud plain intercalations. In this part dominate light grey, fine-grained, flaser-bedded and wavy-bedded sandstones, often bioturbated by Diplocraterion isp; subordinate lenticular-bedded mudstones appear.

(2) estuary mouth with higher energy sediments of channels. In this part dominate sandstones with clay laminas, trough cross-bedded, massive or parallel-bedded sandstones. In upper part of cycles ripple-bedded and herringbone-bedded sandstones are observed; carbonaceous detritus and muscovite occur.

Channel belt planform (low vs. high sinuosity) and behaviour (aggradational vs. laterally migrating) of turbidite channel-levee deposits: insights from the spectacularly exposed Tachrift Turbidite System (Taza-Guercif Basin, Late Tortonian, NE Morocco)

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Turbidite channels are important sediment transfer conduits from shallow-marine environments to deep-water basin floor. They have been the focus of extensive research from a number of modern and ancient deep-water turbidite systems over more than fifty years. Although flow-monitoring at a wide range of locations and high-resolution 3D-seismic studies have recently yielded new insights, their evolution and depositional features are challenging to be deciphered, as they are often characterised by complex three-dimensional facies heterogeneity and depositional geometries at sub-seismic scale. Well-exposed outcrops are crucial in bridging this gap, as they offer insight into small-scale heterogeneities.

This contribution aims to explore from the small-scale facies heterogeneity to the large-scale stacking pattern of superbly exposed leveed-channel complexes which represent part of the clastic infill of the Taza-Guercif Basin (Late-Miocene; NE Morocco). They are up to few tens of metres-thick and intercalated with hemipelagic marlstones, totalling a stratigraphic thickness of ~800m. The project's objectives include the reconstruction of the depositional architecture of deep-water channel-levee complexes, presenting a comprehensive evolution of these complexes from inception to deactivation, and establishing a model for stratigraphic geometries and facies relationships that may improve existing deep-water channel-levee models to be used for modeling seismic analogues.

Preliminary results (based on 1:5000-scale geological mapping and ~250 closely spaced detailed sedimentological logs, physical-correlated) provide valuable insights into facies and geometry of channel-fills and correlative levees over a ~150 m-thick and ~4 km wide transect largely oblique to the main palaeoflow. The study suggests the existence of dominant types of channel belt planform (low vs. high sinuosity) and behaviour (aggradational vs. laterally migrating), which result in two-end member patterns of channel-fill stacking, namely: (a) lateral-migration pattern formed by high-sinuosity leveed channel belts, which shift laterally with minor vertical aggradational, and (b) vertically stacked pattern reflecting the vertical aggradation of low-sinuosity leveed channels.

Facies analysis and anisotropy of magnetic susceptibility (AMS) in the Los Molles and Lajas Formations (Middle Jurassic) of the Neuquén Basin, Argentina

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In this study, a comprehensive facies analysis and anisotropy of magnetic susceptibility (AMS) were conducted on the Los Molles and Lajas Formations at the Carreri creek outcrop in the central Neuquén Basin, Argentina. These two units play a pivotal role as both conventional and unconventional hydrocarbon source and reservoir rocks, respectively. The investigated section in the study area spans approximately 1046 m and encompasses the upper portion of the Los Molles Formation and the entirety of the Lajas Formation. The former comprises deep marine basin turbidite fan successions characterized by black shales interbedded with sandstones associated with classic turbidites, hyperpycnites and hypopycnal plume deposits that evolve upwards to prodeltaic mudstones with erosive slope turbidite channel-levee complexes and overbank deposits. Gradationally upwards, the Lajas Formation is represented by interdigitating delta lobe and mouth bar sandstones and conglomerates of a shelf-margin fluvial-dominated delta system, signifying the regression of the complete second order transgressive-regressive cycle of the Cuyo Group. The study of anisotropy of magnetic susceptibility (AMS) allowed the recognition of magnetic fabrics, applied to determining paleocurrent directions and, consequently, paleoflow and sediment distribution patterns in the deep basin turbidite fan, slope and shelf margin delta system successions. Over 1200 oriented rocks samples were subjected to AMS measurements, revealing a prevailing paleoflow direction towards the northwest throughout the studied section, linked to a northwest progradation trend consistent with previous regional studies by other authors. Additionally, a subordinate paleocurrent direction towards the northeast was observed, underscoring the highly variable dynamic of these types of depositional systems. This research contributes valuable insights into the sedimentological and depositional characteristics of the Los Molles and Lajas Formations, shedding light on the complexity and variability of these critical geological units in the Neuquén Basin.

Study of reservoir heterogeneities by relectance spectroscopy and sedimentology data: the case of oil aeolian sandstones of the Piramboia Formation (SE Brazil)

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Visible and infrared reflectance spectroscopy is now a solid method to study oil reservoirs. The aim of this study is to combine spectroscopy data and traditional stratigraphy approaches to understand the distribution of reservoirs' heterogeneities in aeolian successions. For this study, facies analyses, petrography, and non-imaging spectroscopy (i.e. FieldSpec-4 spectrometer) are performed in bituminous aeolian sandstones of the Piramboia Formation. At outcrop scale, these deposits have no large facies variety, they are essentially composed of well-sorted and well-graded sandstones arranged in simple and compound sets of cross-strata. However, despite the lithology homogeneity, the bitumen accumulation throughout the succession seems to be controlled by: the thickness and distribution of grain-flow strata, in which the grain packing is loose, and the porosity reach up to 21.66% according to petrographic estimation; and the clay mineral content, essentially concentrated in pinstripe lamination/wind-ripples strata, reaching porosity values up to 14.35%. Visible, near-infrared (VNIR, 400-1000nm) and short wave-infrared (SWIR, 2000-2500nm) reflectance data from clay-rich deposits reveal three assymetric absorption features centered at 1420, 1910 and 2200nm. These features are due to the presence of OH, H_2O, and Al-OH molecular vibrations and are typical of montmorillonite. The oil-sand deposits show spectral absorption features around 1700 and 2310nm, mixed with the features found exclusevily on the clayey layers. These features are related to the presence of oil (C-H vibration features) mixed with montmorillonite. Quartz, although pervasively present, only displays distinct spectral features in the longwave infrared (LWIR). In thin sections, dissolution halos in plagioclase grains, which are generally surrounded by thin layers of montmorillonite, suggest the formation of allogenic clay from feldspars' alteration during the diagenesis. The spatial variability of oil-sands is controlled by the clay content and sandstone texture, which leads to the production of an anisotropic permeability and important flow barriers to oil migration and accumulation.

PICS (Petrographical Image Classification System)

Alex Ferro[1]
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The Brazilian pre-salt play is among the most prolific oil provinces in the world and will form a cornerstone of future Equinor production. The pre-salt carbonate reservoirs were deposited under a unique set of geological conditions with limited analogues. Pre-salt exploration and field development has been a major focus since 2006. Such activity has generated a wealth of static and dynamic subsurface data; with the access and visualization of these data being key to success for any IOC (International Oil Company).

As the first IOC to operate a greenfield pre-salt development, Equinor has needed to incorporate external data to help underpin field development decisions, e.g., information with respect to reservoir characterization, levels of data acquisition and production data. Pre-salt data are available through the Brazil Petroleum Agency (ANP) and to efficiently capture this information, the Pre-salt Analytics (PSA) digital platform was conceived.

A feature in PSA is PICS (Petrographical Image Classification System), which is a set of software applications centered on a computer vision model tailored to automatically categorize geological samples in lithology. Leveraging PSA as a docking platform, the primary objective of this project is to investigate the capabilities of automation in classifying pre-salt samples. This enables swift sample assessments, provides insights, recommends potential analogs, and streamlines the integration of field data with our current in-house databases.

Did evaporite cements and infiltrated silts assist preservation of reptile footprints in Permian desert sediments?

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This study on the Permo-Triassic Hopeman Sandstone Formation of Moray, Scotland tests the hypothesis that footprint preservation quality and style are dictated by palaeoenvironmental factors. We describe several footprints and trackways from Moray and discuss petrographic clues in the footprint bearing layers with regard to taphonomy. Key sections at Hopeman Beach, Clashach Quarry and Quarrelwood were logged and sampled. Collected samples were examined optically and with a scanning electron microscope. One footprint-hosting oscillation rippled layer at Hopeman Beach exhibits a halite cement and petrographic evidence for re-worked halite, and these rippled sediments were most likely deposited in an interdunal lake. Other sections exhibit metre-scale planar cross beds and occasional coarser-grained lag deposits that are consistent with aeolian dunes that were episodically inundated by sheet floods. Cutties Hillock Quarry within Quarrelwood is the site of large-scale planar cross-bedded quartz arenites that were deposited in an aeolian dune setting. This study identifies three modes of footprint preservation that are indeed affected by palaeoenvironmental factors in the Permian Moray area: (i) indentation of near-surface layers that were formed by fine silt particles infiltrating between aeolian dune sand grains; (ii) trackways in lake-margin sediments with early evaporite cementation, (iii) indentation of clays deposited in interdunal lakes. Supporting evidence for this will be shown and potential implications for footprint preservation elsewhere will be discussed.

The hidden message of geobiosphere interactions in poly-extreme rift settings : from microbes, salt and corals to rifted margins

PROF Anneleen Foubert

Rifts and rifted margins are fundamental parts of the Earth's crust and shape the continent to ocean transition on much of Planet Earth. They host unique sedimentary archives of paleoenvironmental change required to understand key and complex natural processes such as the initial poly-extreme conditions that led to the development and origin of early microbial life. Moreover, rifts and rifted margins play a crucial societal role in a changing world. Certainly, when it comes to the transition towards a sustainable blue economy (geothermal and hydrogen potential, critical metal resources, and CO2 storage) and the mitigation of risk related to geohazards (seismic activity, volcanic hazards). Considering their societal, geodynamic, geobiological and paleo-environmental relevance, understanding the formation and architecture of rifts and rifted margins, is critical.
This presentation will take you on a journey towards the northern Afar representing a unique snapshot in space and time where the formation of rifts and rifted margins can be studied nowadays. The tight interaction between tectonic processes, volcanic events, climate change, eustatic sea-level variations, hydrothermal fluids and brines, shapes unique (paleo)-environmental and poly-extreme conditions. Being at the transition from continental rifting to oceanization, the limits of life across geothermal gradients can be tested and complex biogeochemical cycling observed. Fast changing paleo-environmental conditions with episodic marine flooding alternating with hypersaline to alkaline lake settings and desiccation provide local ecological niches varying at short temporal and spatial scales. As such, the Danakil Depression forms an exceptional geobiological field lab and unique paleo-environmental archive shedding light on the birth of a future ocean.

Integrated Petrophysics and Sedimentology Studies to Constrain Reservoir Characterization of Albian Mixed-Reservoir – a Case Study from Two Fields in Lower Congo Basin, Offshore Angola

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Hydrocarbon reservoir from mixed carbonate-clastics deposits present numerous challenges. This study investigates such type of deposits of Albian age located in two oil fields from Congo Basin, offshore Angola.

Detailed core descriptions and petrophysical analysis have been conducted to characterize both the deposits and the reservoir properties in terms of shaliness, porosity and water saturation. A clustering approach on well-logs was performed to propagate core information to uncored intervals over the field with electrofacies. We show how this approach improve the definition of dynamic rock-types, from capillary pressure curves and conventional core porosity and permeability, and helps modelling the saturation height.

The lower part of the succession is interpreted as dominantly clastic in a shoreface to nearshore environment, while the upper part appears more carbonate-dominated and is interpreted to be deposited in a lagoonal environment with limited water circulation. The reservoir properties are good (20 % porosity in average) with the southern part presenting better characteristics. Ten (10) electrofacies are obtained from the clustering study on well-logs and five (5) rock-types are determined. The electrofacies can be well tied to the various sandstone and carbonates facies observed on cores. The ten electrofacies correspond to five sandstone, three carbonates and two non-reservoir facies. After grouping into rock-types, the best ones are confirmed to be the shoreface sandstone and vacuolar dolomite.

The reservoir properties characterization has been enhanced by multi-disciplines approach and good data integration, especially using constrains from the depositional model within the two fields in the Lower Congo Basin. This characterization is directly involved in the improvement of subsequent reservoir static and dynamic modeling.

Unusual shallow-water rhodolith bed in the Mar Piccolo basin (Ionian Sea, Southern Italy)

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Mar Piccolo is a semi-enclosed basin located in the Northern Ionian Sea (Southern Italy), with an area of 20.72 km2 and a maximum depth of 13 m. It represents a portion of the coastal sector of the Taranto city area, declared as SIN (Site of National Interest) due to several industries. Mar Piccolo has a rich biodiversity marine ecosystem, with quite low hydrodynamism. A shallow-water rhodolith bed (RB) was recently here discovered. Rhodoliths bio-constructions are very important from numerous standpoints: - a primary role in biogenic habitats and fishery productivity; - a significant contribute to the calcium carbonate budget and to the building of sedimentary environments. They also retain important paleoclimatic information. The development of rhodoliths is related to the quantity of useful light reaching the sea bed, a suitable water motion which can roll and turn rhodoliths, and bioturbation that prevents burial (Foster et al., 2013). In the Mediterranean Sea, RBs are usually present in 30 - 100 m depth range. The Mar Piccolo RB was found in 0.5 - 2 m depth range, an uncommon depth for its development. Considering RBs biodiversity hot spots, the presence of several industries in Taranto strongly impacts on them. For the impact evaluation, scuba diver sampling survey has been carried out and 35 rhodolith nodules has been collected in the area occupied by the RB. All samples with very variable size and shape, were used for studying the relationship between red algae and nucleus. The nuclei are strongly variable and are traceable to three main classes, among which the first is the most represented: anthropic, bioclastic and lithic. Image analysis on photos of macro-slices and thin sections and SEM analysis were carried out to study the nature of the anthropic nucleus. More analysis will be needed to describe the growth processes.

Correlation between geological characteristics of surficial playa deposits and microbial diversity in the Makgadikgadi pans (Botswana): implications for the search for life on Mars

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The current conditions of the Martian surface are considered prohibitive for life as we know it, due to strong radiation, highly oxidizing conditions, and relatively low water activity. Earth hosts a multitude of extreme environments whose physico-chemical properties partly match those currently existing on Mars or occurred over the geological time on the Red Planet. One of such environments, the Makgadikgadi Basin of Botswana, hosts a series of salt lakes (pans or playa) that present geological and chemical characteristics that may offer critical insights for astrobiological studies.
The aim of this work is to characterize the physical and chemical boundaries within which terrestrial life may exist and, by comparison, assess the habitability of Mars.

For the first time, we aim to provide a complete geomicrobiological and mineralogical characterization of the Kudiakam and Ntwetwe Pans (part of the Makgadikgadi Basin) surface sediments, in order to correlate the microbial biodiversity with the geological conditions. In order to achieve this, we measured a number of chemical and physical parameters (pH, alkalinity, conductivity) directly in the field. These were coupled with mineralogical data from XRD and geochemical data from XRF analyses. The data set was transferred into heat maps that were then compared with metabarcoding data in order to highlight correlations existing between physical/mineralogical conditions and the relative abundance/diversity of microorganisms. The sediments were further investigated for the presence of microbial micromorphologies using a SEM in order to provide important baseline data for the taxonomy of extremophiles in hypersaline environments on Earth and on Mars.
This study is of significant interest to astrobiology investigations, allowing to assess the effects of a hypersaline environment on the survival potential of microorganisms and to understand if hypothetical life-forms may exist or have existed on Mars.

New diagenetic constraints for the interpretation of Neoarchean stromatolitic dolostone: implication for the study of Great Oxidation Event onset in Southern Africa

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The stromatolitic dolostones of the Ramonnedi Formation, in the Lower Transvaal Supergroup of Botswana, formed along a shallow carbonate platform during the transition between the Archean and Proterozoic Eons. They are bound to reveal more details on the timing and modes of the Earth's oxygenation process. Nevertheless, their reliability as archives for Neoarchean paleoenvironmental condition depends on the degree of overprinting induced by diagenetic processes and metasomatism.
Here, the focus is on the C-O isotope composition in the laminated stromatolitic dolostones and on S-O isotope compositions in pyrite grains and chert laminations found within the Ramonnedi Formation. The δ13C and δ18O compositions were obtained from powders micro-drilled from laminated dolostone; while the δ34S and δ18O compositions were obtained in-situ from pyrite and chert, respectively, using a virtual SIMS facility.
These novel results complement a long list of analyses performed in the past and reveal that i) δ13C values between -0.52 and -1.41‰, and δ18O values between -8.43 and -14.4‰ are comparable with Archaean values from literature; ii) The carbon isotopes indicate anoxic conditions during the deposition of the Ramonnedi Formation; iii) the pyrite grains are not common in the dolostones and when present have sulphur isotope compositions that point toward abiotic formation, and iii) the stable oxygen isotope composition of the stromatolitic dolostone and from the chert laminae in the upper Ramonnedi Formation indicate diagenetic modification of the carbonate platform.
These results have important implications in the interpretation of the geochemical proxies coming from the lower Transvaal Supergroup carbonate platform and for the interpretation of the onset of the Great Oxidation Event.

Paleoenvironmental significance of glendonites (pseudomorphs after ikaite) in Neogene strata of the northwest Greenland margin

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Glendonites, calcite pseudomorphs after ikaite, a hydrous calcium carbonate mineral, are prominent features of Neogene strata recovered from the northwest Greenland shelf during Expedition 400 of the International Ocean Discovery Program (IODP). The overarching aim of the expedition was to ascertain the evolution and variability of the Greenland ice sheet. In the marine environment, ikaite forms near the sediment-water interface, typically in settings characterized by organic-rich siliciclastic mud with high alkalinity, near-freezing pore water. Once removed from frigid temperatures, ikaite quickly dehydrates to calcite, and thus is found in the rock record as a calcite pseudomorph. Because of ikaite's narrow stability field, the presence of its pseudomorphs serves as a proxy for frigid seafloor conditions. On the northwest Greenland shelf, the pseudomorphs occur as porous blade-shaped or stellate forms up to 10 cm in length, which contain masses of coarse carbonate crystals. Thin section analyses reveal a "guttulatic" internal texture that is typical of glendonites. This texture is characterized by coarse, inclusion-rich hexagonal to spherical calcite crystals, which form during the dehydration of ikaite as it inverts to calcite. The dehydration process leads to a volume change, resulting in a porous structure. Later diagenetic carbonate phases have subsequently overgrown the guttulatic crystals, partially filling remaining pore space. Because ikaite forms (and inverts to guttulatic calcite) near the sediment-water interface, understanding the sedimentological context, petrography, and isotopic composition of glendonites can provide important information about past seafloor conditions. At Sites U1606-U1608 on the northwest Greenland shelf, glendonites occur in several discrete stratigraphic intervals within Miocene and Pliocene strata correlated using seismic stratigraphy. Their restriction to distinct stratigraphic intervals indicates that the frigid conditions necessary for their formation developed during specific periods of time, providing insight into the evolution of paleoclimatic and palaeoceanographic conditions along the northwest Greenland margin.

Active Deepwater Mulitdirectional Tractional Sands at Havre Submarine Volcano; a New Facies Model for Deep Marine Deposition

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The deep ocean is a complex setting where sediment transport and deposition depends on numerous processes, including vertical settling, sediment density currents, and reworking by bottom currents. Bottom currents are traditionally considered persistent flows that can last for thousands of years and are associated with extensive accumulations of sediments (e.g. contourites). However, in deep-ocean settings with significant topography, such as submarine volcanos or seamounts, currents can be steered, deflected, or amplified, significantly affecting sediment deposition. How deep-ocean currents are modified and how this influences sediment deposition at shorter timescales remains under-acknowledged considering the ubiquitous presence of topographic features on the deep seafloor, and consequently is poorly understood. This is in contrast with current deep-ocean depositional models which focus on large-scale and persistent systems. Here, we present very high-resolution bathymetry data (1 m) and extensive seafloor video footage around a deep (>950 mbsl) submarine volcano (Havre volcano, Kermadec arc), coupled with mid-ocean ARGO float data. Havre submarine volcano erupted in 2012, and data from 2015 and 2022 provide exceptional information on the rapid, complex, and commonly ephemeral reworking of silt and sand in deep water, leading to the proposal of a new facies name; Deepwater Multidirectional Tractional Sands (DMTS). DMTS is characterized by chaotic erosional and depositional bedforms that are spatially and temporally inconsistent and do not conform with a single governing hydrodynamic regime. With new estimates showing that large topographic obstacles on the seafloor are widespread and common, the observed phenomena may be more common than anticipated. Additionally, traditional paleocurrent and basin analysis interpretations commonly rely on assumed consistency of bottom-current flow. Our results indicate the need for an improved understanding of complex current, topography, and sediment interactions in the mid- to deep-ocean.

Geothermal Play Concepts of Kazakhstan Sedimentary Basins: Current Status and Future Directions – Needles in Haystacks or Elephants?

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Kazakhstan, the 9th largest country in the world, is among the 20 largest emitters of greenhouse gasses per capita and second in intensity of carbon emissions. A geologically diverse country, including 15 major sedimentary basins that cover two-thirds of its territory, provides an opportunity for the employment of emerging technologies that may allow the nation to become a global leader in green energy. The presence of hot springs and elevated temperatures observed from petroleum wells are traditionally used as evidence of considerable geothermal resources that can be incorporated into the nation's decarbonization strategy. Our recent and ongoing basin-analysis studies focused on the integration of tectono-stratigraphy and advanced water characterization suggests that variable and locally elevated (up to 50 °C) geothermal gradients are primarily related to spatially variable crustal thinning beneath horsts and pull-apart grabens caused by strike-slip faulting. Other heat anomalies are related to water upflows along faults and proximity to uranium mineralization or salt diapirs (capable of storing high-heat content). Sedimentary successions containing porous, permeable, and laterally extensive inter-connected reservoirs and naturally fractured basement and intrusive rocks hold significant quantities of conventionally producible hot water. Fresh water in a majority of studied geothermal aquifers is explained by slow, lateral mountain-block and/or mountain-front recharge of snow-melt and meteoric waters via basement fractures and outcropping reservoirs, respectively. The mixing of these laterally charged, with more saline, downward percolating surface waters is commonly prevented by major aquitards. Compared to large-scale active hot-spot and extensional setting geothermal systems, the play concepts we present may sound like finding needles in haystacks. However, simultaneous development of nearby plays, or coupling them with enhanced or hot dry rock technologies in geothermal sweet spots suggests the presence of elephant-size field-development potentials. Synergy with solar or wind energy, hydro-energy geo-storage, or lithium extraction may further optimize prospect values.

Enhancing the fluvial geomorphology characteristics in the South African Clarens formation area through adaptation techniques

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As climate change poses unprecedented challenges to water resources and landscapes, a proactive approach is imperative for sustainable adaptation. The Welbedacht catchment in South Africa, situated within a region that is largely dry sub-humid with a high erodibility index is vulnerable to climate variability. The Clarens formation is categorized into three notable sedimentary facies, it is known for its distinctive sedimentary rock formations, and is susceptible to the impacts of climate change, necessitating proactive strategies for sustainable landscape management.

The research employed a comprehensive approach, integrating field surveys, remote sensing, GIS mapping and advanced modeling to assess the current state of fluvial geomorphology in the Clarens formation area. By understanding the intricate interactions between climatic variables and river systems, the study aimed to identify vulnerabilities and opportunities for climate adaptation and strategic interventions that enhance the resilience of the landscape.

The adaptation techniques proposed are rooted in fluvial geomorphology principles, encompassing sustainable land management practices, riparian restoration, and engineered solutions to address erosion and sedimentation challenges. Additionally, the study investigated the role of vegetation in stabilising riverbanks, promoting biodiversity, enhancing resilience to climate-induced disturbances and fostering ecosystem health. The outcomes of this research contribute valuable insights for land managers, policymakers, and local communities grappling with the consequences of climate change in the Clarens formation area. By prioritizing fluvial geomorphology as a guiding framework, the study advocates for context-specific and ecologically sensitive adaptation measures that align with the unique characteristics of the South African landscape. The research not only advances the scientific understanding of fluvial systems in the Clarens formation area but also provides practical recommendations for fostering climate resilience. The proposed adaptation techniques aim to balance environmental sustainability with societal needs, ensuring the continued vitality and functionality of the landscape in the face of ongoing climatic changes.

Unveiling Sedimentary Dynamics in the Distal Bengal Fan: Insights from IODP Expedition 354 Core Site U1454b

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The Himalayan-sourced Ganges-Brahmaputra river system and the deep-sea Bengal Fan represent Earth's largest sediment-dispersal system. IODP Expedition 354 (2015) drilled a 7-site transect in the lower Bengal Fan, ~1400 km south of the shelf margin. The work reported here focuses on quantifying physical characteristics of turbidites through time, so as to reconstruct past sedimentary dynamics, and address questions about triggering mechanisms.
We have conducted centimeter-scale description and statistical evaluation of IODP 354 core U1454b, which was collected from a channel-levee system deposited ca. 600-34 Ka. We recognize 137 high-density turbidites (HDTs) with thicknesses up to 3.53 m. We subdivide this core into five units based on discernible depositional patterns, and the assumption that glacial periods of low sea level are necessary for fluvial-to-deep-sea transport of coarser sand. Unit 1 consists of 4% HDTs interbedded with thin low-density turbidites (LDTs) and muddy intervals, and represents an intermittently active levee during high sea level. By contrast, Unit 2 contains 75% HDTs with an average thickness of 0.90 m, which are interbedded with LDTs, and suggest an active levee complex during a glacial period. Similar scenario for Unit 3. Unit 4 features LDTs interbedded with mud, whereas Unit 5 features a predominant silty to muddy layer with limited HDTs. Units 4 and 5 are interpreted to represent a time of sea-level rise and trapping of sands on the shelf, or migration of the channel-levee complex away from the core location. The absence of a discernible cyclic pattern and the presence of large clasts within these 'megaturbidites' intimate potential triggering mechanisms such as seismic activity or slope failures.
We plan to improve geochronological control on turbidite deposition using optical luminescence dating, thereby constraining our interpretative framework in time, and helping us unravel the intricate relationships between climatic influences and triggers for these extraordinary turbidites.

Application of Electron Backscatter Diffraction to the study of the genesis mechanism of fibrous calcite veins within shales

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Electron backscatter diffraction (EBSD) data provide abundant information on the microstructure and texture of both natural and experimentally produced mineral and rock samples, making it a routine technique in the field of materials science. However, its application in oil and gas geology is less common. In this study, the structural characteristics and genesis mechanism of fibrous calcite veins in the Es4s shale of Dongying Depression, China were investigated using polarized light microscopy, cathodoluminescence (CL), scanning electron microscopy (SEM), energy-dispersive X-ray spectroscopy (EDS), and EBSD. Calcite veins exhibit parallel orientation to shale grain layer with thin or lenticular distribution pattern. They are predominantly filled with fibrous calcite in nearly vertical extension direction. Within these veins, there is a central "median line" composed of brown granular calcite surrounded by brown granular calcite and scattered fragments of host rock. Fibrous calcite can be seen on both sides of this median line as well as abundant mud crystal calcites showing layered distribution.
EBSD analysis reveals that the crystal orientation C-axis aligns approximately parallel to the XZ plane of the sample, which corresponds to the vein extension direction and exhibits preferred orientation. The misorientation angle between grains concentrates around 70° to 80°, while certain fibrous calcite grains display significant misorientation with adjacent grains in the GOS Figure. This suggests an interaction between early and late-stage crystals during growth within a vertically extruded environment, leading to stress concentration in some grains and subsequent fractures occurring within or at grain boundaries, resulting in a series of cracks. It can be concluded that bedding-parallel fibrous calcite veins within shale formations result from carbonate dissolution induced by hydrocarbon generation and expulsion processes followed by recrystallization utilizing mud crystal calcite as seed crystals.

A speleothem record of hydroclimate variability during the mid-Holocene Humid Period termination in the southern Iberian Peninsula

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During the early to mid-Holocene Humid Period (HHP, ca. 12 to 4.2 ka), relatively wet conditions prevailed in both northern Africa and southern Europe. While the occurrence of this climatic stage in the Maghreb region of Africa is well-established from speleothem and lake records, uncertainties persist regarding the timing and intensity of the HHP termination in the southern Iberian Peninsula. In this study, we present a subdecadally-resolved stalagmite record (sample SM4) from Simarrón II Cave (1493 m a.s.l., Sierra de Gador, SE Spain), spanning 9.7 to 4.4 ka BP. The stalagmite recorded relatively low δ18Ocarb values from 9.7 to 6 ka, interpreted to have resulted from a wetter climate, possibly linked to greater contributions of Atlantic rain fronts to the overall humidity budget in the region. The subsequent gradual rise in δ18Ocarb at 6.0 ka, followed by stabilization from 5.5 ka and thereafter, implies a shift towards arid conditions. This is likely due to a decrease in winter/spring rainfall contribution compared to the summer/autumn precipitation. This shift may reflect a higher proportion of rainfall events sourced from the Mediterranean Sea, which has higher δ18O values compared to precipitation from the Atlantic Ocean. The increase in δ18Ocarb is accompanied by higher δ13Ccarb values from 6 to 5.5 ka. Concurrently, the Mg/Ca ratio increases by ~50% during the same period. The coeval increases in δ13Ccarb and Mg/Ca ratio suggest enhanced prior calcite precipitation (PCP) in the epikarst conduits over the cave due to increased CO_2 degassing when climate became drier. The SM4 stalagmite record closely agrees with other speleothem records from Morocco and southern Iberia, as well as with marine and lacustrine paleoclimate records from the western Mediterranean region. Our findings underscore the shift to drier winter and spring conditions on the southern Iberian Peninsula during the HHP termination.

Coupling Process Between Tectonic Evolution and Sedimentary Responses of the Cretaceous in Kuqa Foreland Basin， Western CHINA

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According to the recent research on overthrusts at the front of orogenic belts, thrusts and faults propagate intermittently forward to the craton, owing to interplay of accumulating and releasing over pressure. The cretaceous Kuqa depression is a foreland basin generated by flexural subsidence resulting from the thrusting of southern Tianshan Mountains. The Lower Cretaceous recorded an episode of tectonic evolution of a foreland basin. This paper has divided Cretaceous sequence stratigraphy of Kuqa foreland basin into two tectonic sequences based on drilling and seismic. Two different models of sequence stratigraphic framework were established through studying the internal composition of sequence strata and boundary of sequences and corresponding to thrust-faulting activities in the early and in the later stages. In the kapushaliangqun group, this basin appeared as a strong compressive piedmont alluvialhungry basin, a typical foreland basin. The evolution of three depositional system of fan delta, shore-shallow lake and delta have clearly reflects the coupling process between basin and the southern Tianshan mountains fold belt. The coarse gravel sediment in Yageliemu Formation marked the beginning of the thrusting. Because the thrust generated flexural rapid subsidence, the accommodation space increased rapidly, engendered transgressive system. With the weakening of thrusting, flexural subsidence slows down causing rebounded uplift, rivers and deltas moved toward basin, engendered highstand system. In the seismic profiles, the lower and the upper part s of Kapushaliang Group developed propagation reflection forward to thrust-belt and retrogression reflection forward to craton. In contrast, the basin shows smooth and expansive features in the bashijiqike age, and it has a unique model of sequence stratigraphy framework and special internal stratigraphic composition. In the period, with the thrust weakened of southern Tianshan mountain fold belt, sediment supply is greater than the increasing space of accommodation in Kuqa depression.The basin develops alluvial deltas to lakeside sandbars.

A geotechnical view on glacial sediment profiles

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The characterisation and genetic interpretation of glacial (sensu lato) sediment profiles is not always straightforward, especially if observations are limited to the narrow window that a drill core offers. Geotechnical data has proven valuable for, among others, the identification of a glacial sediment component, of previous mechanical loading by ice, or of the modification of a deposit by non-glacial processes. Such data can be gathered with often very simple and cost-effective techniques adopted from applied geosciences, but nevertheless appear to have lost some attention by Quaternary geologists in recent years.

We investigate sediment records from overdeepened basins in the Alpine foreland and in the Black Forest, and routinely apply standard geotechnical methods to reconstruct their deglaciation and, where applicable, phases of readvance. These methods include the determination of:
i) the deposits' shear strength that can be used as an indicator of loading and compaction (i.e. overconsolidation) by an overriding glacier
ii) consistency limits (i.e. water contents at which the sediment's mechanical behaviour changes), which are a measure of the 'glaciality' of a sample and, in relation to its natural water content, further indicators of a potential overconsolidation
iii) the settlement in response to an applied load that allows the determination of a preconsolidation pressure (i.e. a pressure that the sample has previously been exposed to)

iv) water uptake capacities in disturbed and undisturbed state that can provide further information on a sample's internal structure.

We present sedimentological and geotechnical data from several basin infill-profiles, and demonstrate the application and the prospects of, as well as the conclusions that can be drawn from geotechnical testing.

LINKING FLOODS AND RELATED DEPOSITS IN THE HIGH-DISCHARGE VARIABLE POWDER RIVER (MONTANA, USA).

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Understanding the relation between river hydrological characteristics and sedimentation features is a critical issue in fluvial sedimentology, especially in rivers characterized by discharges with high variability. Within this context, it is still unclear whether alluvial deposits represent a time-averaged amalgamation of different floods or simply the outcomes of the largest floods. Consequently, there is a general lack of knowledge regarding the relation between the hydrological characteristics of floods and the sedimentary features of the associated deposits. In order to shed light on this issue we investigated the flood deposits of Powder River (USA). Powder River is a free flowing river that originates in the Big Horn Mountains of Wyoming and flows eastward then northward through the high plains composed of sandstone, shale, siltstone, and coal deposits of Mesozoic and Cenozoic age. Average daily discharge is ~12.7 m3/sec (1929-2022) and it transports 2-3 tonnes of sediment per year ranging from gravels and sand to silts and mud making Powder River an ideal laboratory for study sediment depositional architecture. This study focuses on a meander bend that developed after a cutoff in May 1978. Channel morphological profiles along the bend axis were surveyed almost every year thereafter, and in 2022 a 100m-long trench was cut along the survey profile to expose sediments that had accumulated over the past 44 years. Combining sedimentological, morphological and hydrological data allowed us to identify sedimentary features of annual floods since 1978. Sedimentary features and thickness/lateral extent of definite beds are compared with hydrographs of related floods. Preliminary results show that the amount of accreted sediments, along with their sedimentary features, does not seem to be directly correlated with the peak magnitude of the deposit-forming flood.

Stable isotopic compositions of sedimentary sulphates in the Lower Jurassic syn-rift strata of a continental rift basin of India

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The formation of sulphide and sulphate minerals in marine environments has been studied extensively over the last few decades. In contrast, the processes involved in their formation in continental environments have, so far, received less attention. Here we report the mode of occurrence and stable isotopic compositions of the gypsums and barites in the Lower Jurassic fluvio-lacustrine syn-rift strata of a continental rift basin, the Pranhita-Godavari Gondwana Basin, India. The succession comprises a basal ~450 meters-thick lake-margin siliciclastic deposits, which is overlain by a ~30 meters-thick interval of palustrine deposits (limestones alternating with greenish-yellow mudstones). In the lake-margin deposits, gypsums occur as bed-parallel layers and rosettes in red mudstones. Barite occurs as nodules in laminated greenish-grey mudstones. Pyrite is present in very small amount. In the overlying palustrine deposits, inter-stratal gypsum crystals occur in the laminated mudstones.

The stable isotopic compositions of the gypsums occurring in the basal lake-margin deposits are distinct from those in the overlying palustrine ones. In the lake-margin deposits, $\delta^{34}S$(gypsum) ranges from +22.45 to +24.1‰ and $\delta^{18}O$(gypsum) from +14.37 to +18.1‰. Whereas, in the palustrine deposits the $\delta^{34}S$(gypsum) and $\delta^{18}O$(gypsum) range between -16.1 to -6.28‰ and +6.37 to +8.75‰, respectively. The barites show low variability. $\delta^{34}S$(barite) varies from +30.8 to +31.2‰ and $\delta^{18}O$(barite) from +18.5‰ to +19.3‰. Similar $\delta^{18}O$ values for the lake-margin gypsum and barites suggests precipitation from waters that are far more enriched than meteoric waters. Surprisingly, the sulphur and oxygen isotopic compositions of these freshwater sedimentary sulphates are similar to those reported from hydrothermal and cold-seep environments. The marginal fault systems of the rift basin possibly facilitated entry of enriched geothermal waters to the depositional basin. Whereas the depletion of ^{34}S and lesser enrichment of ^{18}O in gypsum of the palustrine deposits might indicate pyrite oxidation and evaporative enrichment of the meteoric water.

A 400m thick salt unit in the Granada Basin (SE Spain): a latest Miocene marine to continental evaporite record

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The Granada Basin, in southern Spain, contains a 400m thick evaporitic unit at its depocenter that mainly consists of halite with minor anhydrite, while the margin of the basin is rich in gypsum deposits. Those evaporitic units were accumulated during the continentalization of the Granada Basin in the late Miocene. These 400m halite deposits, known as Chimeneas Halite, are not found in outcrops but were cut by three exploratory drill cores up to 800m deep. Here we present new petrographic, geochemical and biostratigraphic data of these cores to interpret the restriction process of the Granada Basin. Stable sulphate isotopes (δ34S and δ18O), Br concentration, and 87Sr/86Sr ratios indicate an increase in the continental water inputs, related to the progressive restriction of the basin from the sea. Planktonic and benthic foraminifera present in the pre-evaporitic marls allow a correlation with the outcropping marls associated with gypsum in the basin margin of the basin and place the onset of the Chimeneas Halite in the Latest Tortonian. In addition, the benthic foraminifera assemblage gives information about the basin paleobathimetry before the evaporitic sedimentation. Inside the halite unit, characteristic coarse-fine halite alternations, similar to those described in the Dead Sea, indicate seasonal evaporite cycles. These cycles are more common in the deeper areas of the basin than towards the margins, as occurs today in the Dead Sea. We propose that these evaporites were deposited in a restricted and high-evaporated lagoon with progressive disconnection to the open sea that produced halite deposition in the depocenter of the basin and bottom-grow selenitic gypsum deposits on the margins.

Ancient seep carbonates hosting pseudomorphs after gas hydrate and ikaite (Outer Carpathians, Poland)

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Polygonal-shaped pseudomorphs composed of multiple calcite crystals were detected in Oligocene seep carbonates from the Outer Carpathians, Poland. The seep carbonates are mostly represented by mono- and polymictic carbonate breccias showing multiple stages of brecciation, fluid flow, and cementation. The pseudomorphs are accompanied by druses previously interpreted as clasts of former gas hydrates replaced by calcite. The pseudomorphs are herein interpreted as derived from ikaite ($CaCO_3 \cdot 6H_2O$) crystals based on i) their morphology, which is similar to the reported ikaite crystals, and ii) the presence of guttulatic microtexture. The former presence of gas hydrate in the studied paleoseep indicates near water-freezing temperatures. High alkalinity and relatively high phosphate concentrations, the other major preconditions for ikaite formation, are testified by the organic matter-rich environment and the low $\delta^{13}C$ values of the seep carbonates, which in turn imply anaerobic oxidation of methane. Here, we present petrographic and stable carbon and oxygen isotope data for these ikaite pseudomorphs and propose a palaeoenvironmental interpretation for the origin of these rocks. We suspect that gas hydrate and ikaite could be more common in methane-impacted sediments at low temperatures than currently reported possibly due to the ephemeral nature of both ikaite and hydrate. This work was funded by the National Science Centre grant no. 2020/37/B/ST10/01769.

Formation and Distribution of Thick Microbial Encrusters on Pleistocene Corals from The Bahamas and Their Role in Porosity Occlusion of Coral-rich Subtidal Carbonate Deposits

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Exposures of the Grotto Beach Formation in Cockburn Town on the west coast of San Salvador Island, Bahamas, reveal thick microbial encrusters on Acropora cervicornis corals below the Devil's Point Discontinuity (DPD) that separates two stages of the last interglacial (Eemian/MIS 5e) reef development. Corals were first coated with skeletal encrusters (coralline red algae, serpulids, foraminifera), and then overlapped by microbialites that become more extensive (up to ~15 cm thick) upward toward DPD and consist of stromatolites on the upper sides of corals and clotted microbialites engulfing the coral branches. Stromatolites incorporate fine-grained skeletal-peloidal-ooid sand within the micritic laminae whereas clotted microbialites have patches of micrite with irregular fenestrae and medium- to coarse-grained carbonate sand.

In contrast, exposures at Devil's Point on the west coast of Great Inagua Island lack thick microbialites and reflect differences in MIS 5e reef development in the Bahamas. Even though DPD is not pronounced in the core from The Gulf on the south coast of San Salvador, the uppermost reef interval in the core contains branching A. cervicornis with U/Th dates indicating MIS 5d-e age (~111-119 kya), and extensive microbial encrusters (up to ~14 cm thick and slightly younger ~104-108 kya +/-1.5-2 kyr).

Petrographic, porosity, permeability, density, and image analyses reveal the significance of microbialites in porosity occlusion of these coral-rich deposits. The association with encrusting foraminifera and macroborings indicates that microbialites enhanced rapid and firm lithification. Other stratigraphic (e.g., timing of formation relative to MIS 5e highstand) and geochemical (elevated $\delta^{18}O$ and $\delta^{13}C$ values) indicators suggest that elevated organic productivity and thick microbial encrustation were favored by lower sea level and increased restriction and nutrification during post-storm run-off in a nearshore back-reef setting. We continue to test these hypotheses through re-examination of a 1997 core from Cockburn Town and microbial biomarker analyses.

Making evaporite data FAIR – The Iberian Evaporite Structure Database (IESDB)

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Evaporite formations are considered key geological assets due to their unique physicochemical properties. They flow under relatively low differential stress, thus controlling the structural and stratigraphical architecture of basins and orogens. They also act as hosts of different types of ore deposits, such as Lithium, and play an important role in petroleum systems. Furthermore, evaporite structures may be suitable subsurface storage sites for energy, CO2, or nuclear waste, which are key elements for the Energy Transition. A systematic characterization of evaporite structures is thus key for the development of geoscience-based technologies to address societal challenges. However, vast amounts of data related to evaporite structures are often segregated and, sometimes, inaccessible beyond paywalls or company restrictions. The Iberian Evaporite Structure DataBase (IESDB; https://iesdb.eu; González-Esvertit et al., 2023) represents the first assessment focused on evaporite structures from any region of the world. It is sourced from >1,500 scientific documents and databases and includes information of 150 evaporite structures in Spain and Portugal. Data are compiled in >450 information fields per structure with information about the stratigraphy, structure, chronology, subsurface data, mining activity, and references. The IESDB follows the FAIR principles of database management (Findable, Accessible, Interoperable, Reusable) and is presented as an open-access webpage where indexed structures can be easily selected from a map or filtered by a search engine. The IESBD can act as a dynamic resource for earth science teaching, academic research, and for the sustainable exploration and appraisal of mineral resources and Geo-Energy applications. The framework established by the IESDB is an opportunity to boost the scientific research on Iberian evaporites to tackle important societal challenges. Additionally, it can also foster similar initiatives in other regions.

Reference: González-Esvertit, E., Alcalde, J. and Gomez-Rivas, E. 2023. IESDB – The Iberian Evaporite Structure Database. Earth System Science Data, 15, 3131–3145. https://doi.org/10.5194/essd-15-3131-2023

Genesis and Tectonic Evolution of Arc Faults in Qingxi Area of Dongying Depression

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The tectonic activities in Qingxi area of Dongying Depression are of great complicated, and numerous arc faults intersect with other faults to form complex fault-block traps. These faults play a crucial role in controlling trap formation, evolution, as well as the migration and accumulation of oil and gas. Therefore, a comprehensive study of the genesis and tectonic evolution of arc faults in this area is of paramount importance. Through detailed three-dimensional seismic analysis, the static characteristics of arc faults are delineated, and their typical tectonic styles in planar and sectional dimensions are defined. Subsequently, fault kinematics properties are analyzed through fault activity calculations. The developmental characteristics, active characteristics, and genetic mechanism of arcuate faults are examined in conjunction with structural evolution restoration methods. On this basis, the formation, development process, and genetic mechanisms of arc-shaped faults are analyzed. The results indicate that the arc faults exhibit an en-echelon pattern in the plane, with a roughly ladder-like distribution of normal faults in the section. This is attributed to the dual effects of gravity and strike-slip. Since the late Eocene, the study area has been dominated by extensional fault depression, leading to the development of normal faults. Later, from the end of late Eocene to early Oligocene, the strata underwent folding and deformation due to mudstone arch stretching and fault tilting, resulting in the evolution of sediments into reverse drag anticlines under continuous tectonic tension and gravity, forming stepped normal faults. Finally, in the late Oligocene, tectonic activity stabilized, and faults gradually ceased developing. Under the influence of strike-slip shear, the extension rate at both ends of the fault was smaller than that in the middle part, leading to the current arc-like appearance in the plane.

The deep-time roots of the Skolithos and Cruziana ichnofacies

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Since their original definition by Seilacher in 1967, ichnofacies have been popular among ichnologists and sedimentologists to understand the response of animal communities to sets of environmental conditions. Seilacher initially proposed four softground marine ichnofacies which are still considered valid today, with some refinements. The Skolithos and Cruziana ichnofacies are particularly instrumental as they are regularly identified in Phanerozoic shallow-marine deposits, but their origins and earliest expressions have not been clearly assessed so far. In this study, we revisited the Ediacaran–Cambrian Age 2 Chapel Island and Cambrian Age 2 Random formations of Newfoundland, Canada, and the Floian Armorican Sandstone and Katian Kermeur formations of Crozon, France, to evaluate the early expressions of the Skolithos and Cruziana ichnofacies. Time-environment matrices were designed based on extensive sedimentary facies analyses to allow for the discrimination of environmental and evolutionary signals. During the Ediacaran, trace fossils in environments typically represented by the archetypal Cruziana Ichnofacies were simple, poorly diverse and of limited ethologic types, therefore lacking the diagnostic characteristics of this ichnofacies. A burst of diversity and disparity in horizontal trace fossils in Fortunian offshore environments signals the oldest expression of the Cruziana Ichnofacies, characterized by the onset of more specialized deposit- and detritus-feeding strategies as well as an increase in the variety of ethologies represented. The establishment of the Skolithos Ichnofacies was delayed, with its oldest expression evidenced in Cambrian Age 2 shoreface deposits and the presence of sparse vertical burrows (e.g. Arenicolites isp., Rosselia erecta). These trends continued into the Ordovician, and none of the intervening extinctions events impacted on the Cruziana and Skolithos ichnofacies in any significant way. This study shows that the ichnofacies concept is robust if performed alongside detailed sedimentary facies analysis and with an accurate understanding of macroevolution.

Insights from a channel-lobe-transition zone, Storvola, Spitsbergen

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The zone connecting deep-water feeder channels to their depositional lobes, commonly referred to as the channel lobe transition zone (CLTZ), has received considerable attention in the literature. In recent years, there has been renewed interest in processes and deposits of the CLTZ due to increasing amounts of high-resolution bathymetric data as well as subsea monitoring data. However, the resolution of such data is still too low to resolve processes responsible for lamina- to bed-scale facies. In this outcrop-based study of the renowned Clinoform 14 of Storvola, Spitsbergen, we investigate various gravity flow deposits by tracing their facies tracts from the shelf-edge, across the slope and onto the basin floor. We present detailed sedimentary logs and photo panels that capture architectures and depositional elements from various slope segments, particularly focusing on the CLTZ at the base of slope. The CLTZ of Clinoform 14 is characterized by a wide range of gravity flow deposits, scours and other by-pass features, reflecting the dynamic nature of the CLTZ. Depositional lobes basinward of the CLTZ intriguingly exhibit facies indicative of deposition by quasi-steady hyperpycnal flows operating under fluctuating subcritical to supercritical conditions. Our study area is located on the remote Arctic Island of Spitsbergen, the largest island of the Svalbard archipelago, in a small (40x60 km) foreland basin of Paleogene age. Clinoform 14 is part of a series of shelf-prism-scale clinoform units that traversed and eventually filled the basin during the Eocene. Despite many previous investigations, there are few published details from the CLTZ of Clinoform 14. As such, our study sheds new light on an important segment of one of the most studied clinoforms on the planet, but also explore the general relationship between slope and basin floor processes and examine the role of hyperpycnal flows in deep-water sediment transfer.

Decoding Earth's Depths: A Quantum Leap in Sedimentology through Machine Learning-Driven High-Resolution Core Analysis

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Sedimentology unveils the geological history through the sedimentological features such as grain size, sorting, roundness and sedimentary structures like Cross stratification. Traditional methods, such as seismic data and well logs are unable to efficiently analyze the subsurface sedimentological features. Drill cores yields sufficient information about the subsurface sedimentological features and structures. Our research pioneers a revolutionary approach by integrating machine learning with high-resolution core analysis. Cores provide direct information about subsurface sedimentology. The machine learning model was trained at sub centimeter level from 285m of core. ML model was built in python and have satisfactory capability to analyze the core image. This powerful integration pushes the boundaries of resolution and accuracy, unveiling the Earth's geological intricacies in unprecedented detail. The machine learning model achieves over 90% accuracy in lithology predictions, while the color channel log attains an 85% accuracy in classifying sandstone and mudstone—exposing a level of detail unmatched by conventional methods. Comparison of core-based machine learning lithological prediction with log-based lithological interpretation shows that former technique is quite better in resolution and accuracy of results. Particularly transformative in regions abundant with core images, our methodology provides a reliable, centimeter-scale lens into subsurface sedimentology. Achieving centimeter-scale resolution in identifying potential hydrocarbon-bearing zones not only facilitates the adoption of improved exploration strategies but also enhances control over subsurface conditions, a critical factor in devising efficient production parameters. While our machine learning model showcases impressive results, acknowledging the ongoing need for refinement is crucial. This research represents a watershed moment in hydrocarbon exploration, where machine learning emerges as a transformative tool poised to unveil the Earth's hidden treasures with unprecedented precision. Our approach, marrying technology and geological understanding, marks a new era in which hydrocarbon exploration gains unprecedented clarity and efficiency, propelling the industry towards future of unparalleled discovery and production optimization.

Sediment Routing in the Neogene Ogallala Formation of the North American Great Plains from Detrital Zircon U-Pb Data

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The Neogene Ogallala Formation records deposition by a diverse group of fluvial systems in central North America after the uplift of the Laramide Rocky Mountains. The Ogallala spans the western US Great Plains from Nebraska to the northern part of Texas and consists of compound terrestrial deposition like conglomerates, fluvial and eolian sands, and volcanic tuffs. These deposits shaped the topography of the western Great Plains and formed the High Plains Aquifer, the most essential water-bearing strata in North America.
This study introduces new detrital zircon (DZ) U-Pb geochronological data that was collected to examine the Neogene sediment routing system of the western Great Plains. We collected and analyzed samples from 13 Ogallala outcrops over a north-to-south distance of >1000 km, along with modern bar sands from major Great Plains rivers. In total 31 samples were submitted to the Arizona LaserChron Center for LA-ICP-MS analysis of DZ U-Pb ages, with ~600 zircon grains targeted per sample. Multi-dimensional scaling (MDS) and non-negative matrix factorization (NNMF) were deployed as analytical tools to identify provenance signatures and patterns of sediment routing.
DZ U-Pb data show the primary sources for Ogallala sediment are erosion of the Laramide Rockies and recycling of Cretaceous and older basin fills. These data also define distinct northern, central, and southern subregions based on variations in DZ U-Pb age distributions. Notably, the otherwise ubiquitous Mesoproterozoic Grenville zircon grains (ca. 1250-950 Ma) primarily occur in the central subregion, while zircon grains from the Midcontinent anorogenic province (ca. 1550-1350 Ma) are sparse in the southern subregion. DZ U-Pb signatures from modern river sands illustrate both a continuity in provenance signatures between ancient and modern rivers in parts of the region, while some uninherited signatures also indicate potential river captures happened in the past 5 Ma.

Architecture of a Continental Scale Axial Fluvial Channel-Belt – Chinle Formation, Canyonlands, Utah

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Axial fluvial systems comprise an important component of continental sedimentary basin fill successions yet their recognition and distinguish from other fluvial systems such as distributive and valley-fill maybe problematic as they may all comprise laterally amalgamated, multistorey channel-belt sandstone bodies. Here we develop criteria that can be used to recognise axial systems through an analysis of the continental scale fluvial system preserved in the Chinle Formation, Canyonlands, Utah. We utilise UAV data to map channel-belt and floodplain development orthogonal to regional paleoflow along a 6 km transect and parallel to paleoflow along a 2 km long transect. Preserved point bar deposits indicate channel bank-full flow depths of up to 13 m with preserved channel-belts >5.6 km in width, and width thickness ratios between 1:260 to 1:520 with an average of 1:400 (although it should be noted that due to outcrop constraints that these are minima). Channel belt deposits may be either isolated within floodplain and splay deposits, display offset stacking or vertical aggradation of up to 3 stories. Floodplain deposits comprise mudstone with mature paleosols and highly bioturbated intervals with well developed lungfish burrows. Splay deposits comprise thinly bedded sandstones but may be composed of intraclast conglomerates.
The studied section comprises part of the Upper Chinle-Cottonwood drainage system considered to form part of a regional scale palaeovalley. Criteria that argue against a palaeovalley include: the absence of a reginal erosion surface that bounds the channel-belt deposits and the interbedded nature of the channel belt sandstones with mature paleosols and extensive bioturbated horizons. The latter indicates long periods of non-deposition between channel belt return periods. Based on dating of the Chinle Formation elsewhere broad ranges can be put on the reoccupation time of the axial system using conservative estimates these are between 500,000 and 2 million years.

Early rift development and palaeo-environments of the easternmost part of Corinth rift (Greece): IODP Expedition 381 Site M0080.

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Cores recovered during IODP Expedition 381 in the Gulf of Corinth provide a high-resolution record of syn-rift stratigraphy that capture both tectonic activity and climatic variations during the incipient stage of continental rifting. The drilled site M0080 penetrates the basal syn-rift succession in the Alkyonides and enables to decipher the evolution of the normal fault system that bound it, as well as the relationship with the onshore Megara Basin (located 10 km to the East). The basal succession of Site M0080 consists of a fining-upward sequence (90 m thick) from alluvial to sublittoral carbonate-rich deposits, characterised by high frequency base level variations. Within this sequence, a U-Pb age of 5.18±1.01 Ma was obtained in charophytes-bearing calcareous siltstones. The overlying succession consists of a coarsening-upward fluvial sequence (200 m thick) that documents the development of axial drainage and progradation across the rifted margin. This new isotopic age coupled with palaeomagnetic data and other age constraints aid stratigraphic correlation between the deep syn-rift succession penetrated by M0080 beneath the Alkyonides Gulf and the onshore Megara Basin. Our maps of palaeo-environmental reconstructions at 3.0 and 4.5 Ma show a shift in the locus of fault activity from the Megara Basin to the Alkyonides Gulf, as well as a shift from transverse drainage to axial drainage during early rifting. The development of axial drainage probably allows early connection with the Corinth lake Basin. Moreover, we interpret an offshore hiatus between ca 2.2 and 0.8 Ma, which would correspond to an uplift phase due to fault activation in the Alkyonides Gulf. Later marine sedimentation marks basin deepening, activation of the Alkyonides fault system and final abandonment of the Megara Basin. This work represents a first step towards a better quantification of early rift processes in the resultant sedimentation.

Revisiting basal Torridonian stratigraphy and facies associations, Wester Ross Supergroup, NW Scotland

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The newly named Wester Ross Supergroup (WRSG) encompasses units deposited c. 1000 – 950 Ma adjacent to the Grenville orogenic belt, today exposed in NW Scotland. Two key units within the WRSG are the ‘Torridonian’ Sleat Group and the Torridon Group, whose lowermost strata belong to the dominantly lacustrine Diabaig Formation (DBF). The Sleat Group and the DBF were deposited in palaeotopographic lows formed after surface-erosion of the Archean-Palaeoproterozoic Lewisian gneiss basement. Although Torridonian fluvial units have been studied in detail in recent years, a similar reappraisal of the basal lacustrine units (DBF) and the Sleat Group is overdue. Our field study of the DBF reveals new facies associations. Coarse members record varying styles of fluvio-lacustrine deposition depending on proximity to palaeovalley margins and fluvial input sources. Some marginal environments were commonly subaerially exposed and record evidence of subaqueous sedimentary stasis, including MISS, while others were submerged and show little evidence for sedimentary stasis . Breccia-type deposits at lake margins were variably deposited as relatively static alluvial fans , debris-flow deposits or cliff-fall deposits. At the transitional contact between the DBF and the overlying Applecross Formation, supercritical bedforms are widespread and include stable and unstable forms of antidune stratification, chute-and-pool structures, and cyclic steps, each with accompanying evidence of rapidly waning flow conditions archive¬d by capping subcritical, ripple cross-laminated bedforms. These bedforms provide insight into the style of deposition which generated the uppermost infill of palaeotopographic hollows in Lewisian basement gneiss. Many facies show remarkable similarity to those of the Sleat Group, with new Sr–Nd isotope data demonstrating shared provenance. Taken together, these observations paint a finer-grained picture of the early Torridonian landscape, whose lakes hosted Earth’s earliest known non-marine eukaryotes and represent one of only a handful of similarly aged successions reported worldwide.

Quantifying porosity and permeability enhancing grain-coating clays in 3D using X-ray Computed Tomography (XCT): an example from the Tilje Formation, Norwegian North Sea

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Clay minerals present as coats on the surface of sand grains are reported to exert a fundamental control on the diagenetic and reservoir characteristics of deeply buried sandstones. Clay grain coats on sandstones are able to preserve primary porosity through the inhibition of pore-filling, authigenic quartz cement. Leading to anomalously high permeability in deeply buried sandstone reservoirs. The completeness of a clay coat is the primary factor controlling the inhibition of quartz cement and the preservation of primary porosity. Therefore, the ability to quantify the coverage of clay grain coats is highly important for the modelling of clay coat distribution enhanced reservoir quality.

Clay coat identification and quantification is traditionally achieved through optical point counting of thin sections and scanning electron microscope (SEM) images. The existing methods focus on quantifying clay coat coverage in 2D, potentially neglecting the true coverage of clay grain coats.

Here we make the first attempt to identify and quantify clay coat coverage in 3D using XCT data from a deeply buried sandstone with chlorite grain coats. XCT is a method to image the 3D volume of a sample and show the differences in x-ray attenuation of the materials within a sample. A sample is rotated over 360 degrees and the projection images are processed to mathematically produce a tomographic 3D volume. The workflow used whole rock samples, scanned at a resolution of 0.38 µm, producing images comparable to SEM data. XCT data is segmented using a semi-automated workflow into five phases, isolating the clay grain coats from sand grains. Clay grain coat coverage, alongside other metrics, is then calculated from the segmented volume.

Extracting Geometric Data from Virtual Outcrops for Reservoir and Aquifer Modelling

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[1]University Of Aberdeen, [2]Badley Ashton and Associates , [3]OMT , [4]Rock Flow Dynamics

The geometry and architecture of sedimentary bodies are the fundamental control on fluid flow in subsurface reservoirs, aquifers and repositories (RARs). In the subsurface, data are typically taken from wells or boreholes which provide limited insight to the critical geometry. Outcrop analogues provide information on the sedimentary architecture that is a key part of building geostatistical models of the subsurface to predict fluid flow and storage capacity. Virtual outcrops are now routinely used to capture key analogue sections and can be used to extract geobody dimensions and spatial relationships.

For subsurface RARs, geobodies are modelled using a number of statistical approaches including boolean (object-modelling) which require object dimensions; Indicator simulations, which require semi-variograms and, texture-based or multi-point statistics which utilise training images. In this presentation we illustrate systematic approaches to extracting all of these data types from virtual outcrops.

In addition we describe a novel method for analysing facies proportions from virtual outcrop data. This method calculates the facies proportions from a series of equally spaced vertical profiles along the outcrop and then displays a probability density function for each facies. The spread of the pdf is related to the lateral variability within the system. A narrow spread suggests the system is layer cake while a wider spread suggests a high degree of facies variability and equates to greater subsurface heterogeneity.

These approaches are illustrated with examples of data extracted from a range of virtual outcrops from continental, shallow marine and deep water clastic depositional systems.

Reevaluating Marine Isotope Stage 5a and 5c paleo-sea-level trends from additional U-Th coral constraints across the Florida Keys Reef Tract, Florida

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Establishing depth and timing of local sea-level changes from tectonically stable regions, such as the Florida Keys Reef Tract (FKRT), are critical for calibrating Glacial Isostatic Adjustment (GIA) trends and reconstructing Global Mean Sea Level (GMSL). Estimates for Marine Isotope substages (MIS) 5a and 5c, postdating the well-documented MIS 5e, show considerable uncertainty and sparse data due to the concealment of datable in-situ coral facies from these substages by MIS 1 deposits and inaccessibility from submergence by modern sea level.

To resolve this paucity of data, a unique dataset of twenty-three United States Geological Survey (USGS) cores from the FKRT that recover over 170 m of section is the focus of this contribution. Following detailed facies description, thirty-four in-situ, minimally altered aragonitic coral samples were targeted for U-Th geochronology. Samples below the Holocene-Pleistocene boundary and bounded above by radiocarbon-dated Holocene corals underwent XRD screening (≤2.7 % calcite).

U-Th dates measured using a Multi-Collector Inductively Coupled Plasma Mass Spectrometer (MC-ICP-MS) yielded 20 MIS 5a (85-81ka) and 3 MIS 5c (99-104ka) ages (2σ ±<200 years). Although this study supports the conclusion that 5a sea level likely peaked ~83ka, the presence of four Orbicella spp. in two cores from the Middle and Upper Keys, at elevations between -6.93±.54 and -7.40±.54 m MSL (subsidence corrected) suggests 5a sea level peaked at least ~2 m higher than previous estimates of -9 m before reef cessation and SL regression. Similarly, MIS 5c Acropora palmata at 10.65±.54 m suggests 5c sea level peaked higher than previously dated deeper corals. Data from MIS 5a coral found consistently along four subregions of the Florida Keys adds significantly to resolution and regional sea-level reconstruction of the only recorded tectonically stable region of 5a and 5c in-situ reefal deposits.

DDE OneSediment: a future sedimentological database and research platform

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OneSediment is a disciplinary data product planned by the Deep-Time Digital Earth (DDE) international big science program, which aims to integrate sedimentological data scattered all over the world, of different sources (journals, books, reports) and of different categories (analyzing data, text, images, etc.).

The construction of OneSediment is based on the knowledge system of sedimentology and paleogeography, by using cloud technology, big data and other technologies to meet the globally needs of data building and sharing. The establishment of a dynamic database with unified standards and platforms, in line with the principles of FAIR (Findable, Accessible, Interoperable, Reusable), promote the digitalization and standardization of sedimentological data, and provide sedimentological data services for the public.

OneSediment will integrate databases of different scales, construct by interested scientists, and realize data interoperability and interconnection through a unified OneID. OneSediment is being built to provide a one-stop scientific data serves for calculations, statistics, visualization, mapping and simulations.

Up to now, 25 thematic databases have been constructed under the joint efforts of the DDE Sedimentology and the Paleogeography working groups. For example, the ocean sediment database (OSD) is under construction, including nine core data categories, totaling 583 standard fields, related to sediment composition (macroscopic, microscopic, clay minerals), sedimentary geochemistry (organic geochemistry, inorganic geochemistry, pore water chemistry), physical properties (moisture and density, diffuse reflectance color), stratigraphic event data for age-depth models, with 2,247 sedimentary boreholes and a total of more than 1,630,000 data entries.

Another example is the global detrital zircon database with approximately 600,000 U-Pb age data mainly from China, Iran, Turkey and Cyprus, which had been published recently in Geoscience Data Journal, together with the global deep-time sandstone detrital component database, modern river sediment composition database, global chert database. Chinese Sedimentological Microscopic Images database was constructed and published in Chinese Science Data.

Study on the Evolution of Diagenetic Fluids in the Paleogene Near Source Glutenite Reservoirs, Bozhong Depression

Study On The Evolution Of Diagenetic Fluids In The Paleogene Near Source Glutenite Reservoirs, Bozhong Depression Jin Hu[1], Study on the Evolution of Diagenetic Fluids in the Paleogene Near Source Glutenite Reservoirs, Bozhong Depression Shouyu Xu[1], Study on the Evolution of Diagenetic Fluids in the Paleogene Near Source Glutenite Reservoirs, Bozhong Depression Guanmin Wang[1]
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The law of development of near source glutenite reservoirs is complex, and the properties of diagenetic fluids have an important impact on the diagenesis and physical properties of the reservoir. This study analyzed the diagenetic fluid properties and diagenetic of the reservoir through thin sections, cathodoluminescence, scanning electron microscopy observation, fluid inclusion testing, carbon and oxygen stable isotope analysis, X-ray diffraction, etc. In a relatively closed diagenetic fluid system. In the early diagenetic stage, the formation fluid tends to be alkaline, resulting in the cementation of bright calcite, heavy carbon isotopes, and minimal dissolution of particles. In the middle diagenetic stage A1, multiple layers of source rock undergo thermal evolution to generate acid, and the formation fluid rapidly turns acidic. The composition of clay minerals undergoes suddenly, with organic acids and CO_2 entering the reservoir, feldspar and lithic fragments undergo widespread dissolution under H^+ substitution and carboxylic acid anion complexation, resulting in secondary pores. Simultaneously, siliceous cementitious materials and authigenic minerals of kaolinite are formed widely, carbonate cementitious materials undergo minor dissolution. In the middle diagenetic stage A2, the ground temperature exceeds 120 ℃, the acid generation ability of the source rock is depleted, the organic acids in the formation undergo decarboxylation and decomposition with increasing temperature, and their concentration gradually decreases, the pore water is mainly alkaline. K^+ released by feldspar dissolution and enriched in pore water is fixed in clay minerals, and the relative content of illite increases rapidly. Carbonate mineral cementation is common, and carbon isotopes are relatively light. There is also cementation of sodium feldspar, dissolution of quartz particles and enlarged edges. In relatively open diagenetic fluid systems, atmospheric freshwater leaching plays a strong role in transformation.

Sedimentary mercury enrichments as a paleovolcanism proxy: depositional biases and a robust quantification approach

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Mercury (Hg) anomalies in sedimentary rocks have been increasingly used in paleoclimatology studies for tracing volcanic signals, because Hg emissions from volcanic activity could cause contemporaneous sedimentary Hg enrichment. However, non-volcanic controls on Hg, such as host phase variability, facies changes and post-depositional preservation effects, can be significant. These factors can limit the efficacy of Hg as a volcanism proxy. In this study, Hg and multiproxy geochemical data through an end-Triassic terrestrial to marine succession from southwest England (St. Audrie's Bay) have been analyzed. This studied interval was contemporaneous with volcanism from the Central Atlantic Magmatic Province (CAMP). We specifically examine how changing sedimentary environments affect the behavior and preservation of Hg. We show that transitions of Hg host phases through the section can be linked to changing sedimentary environment, and distinct and significant changes in Hg abundance can be linked to variations from evaporitic lacustrine, shallow marine, and euxinic marine. A statistical analysis of Hg abundance and our associated geochemical data also indicates that subaerial exposure and oversupply of Hg host phases can lead to further alteration of Hg and Hg/host phase signals. To help mitigate these issues, we present a statistical method for quantifying Hg anomalies to more robustly distinguish Hg variations linked to environmental/post-depositional changes from volcanism. Using this method, we confirm that no anomalous Hg enrichment occurs across the end-Triassic mass extinction interval at St Audrie's Bay, despite deposition of our studied succession relatively close to CAMP volcanic activity. However, our method does support the existence of short-lived (and likely asynchronous) Hg anomalies linked to CAMP volcanism across other globally distributed end-Triassic sections.

Middle and Upper Jurassic sequence stratigraphic framework of the Adriatic Carbonate Platform, Croatia

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The Adriatic Platform was a Bahama-type platform that developed on the Adria Microplate during the Mesozoic. Despite being one of the largest southern Tethyan isolated carbonate platforms, its high-resolution sequence framework, except at the scale of 2nd-order sequences, is only partially known. Here, we focus on the relatively continuous, ~1.9-km-thick, ~30 myr record of the Middle and Upper Jurassic Adriatic Carbonate Platform in southern Croatia. We logged in detail nine road-cut and mountain-side sections (45 to 700 m thick), and sampled lime mudstone for carbon and oxygen isotopes. The $\delta^{13}C$ profiles were generated to help constrain the biostratigraphically determined ages, matching the excursions with those on published $\delta^{13}C$ profiles. Identified excursions include the BjBaE (Bajocian-Bathonian), CaOxBE (Callovian-Oxfordian boundary), EOxE, and MOxE (Early and Middle Oxfordian). The similarity of the absolute $\delta^{13}C$ and limited evidence of meteoric diagenesis below the unconformities, suggests that the studied carbonates likely preserved the original $\delta^{13}C$ signature.
The succession has three supersequences that span (1) the Toarcian to basal Callovian, (2) the Callovian-Kimmeridgian, and (3) the Tithonian. The supersequences are made up of cyclic subtidal interspersed with highly cyclic peritidal units. Poorly cyclic subtidal intervals commonly occur within the 2nd- and 3rd-order transgressive systems tracts: the upper Toarcian-lower Aalenian interval, a short interval just above the middle Bathonian and in the basal Callovian, the thick Oxfordian interval, much of the lower Kimmeridgian, and the lower Tithonian. Highly cyclic peritidal units are associated with long-term highstands in the upper Bajocian-lower Bathonian and short intervals in the upper Kimmeridgian, and with a long-term sea-level fall in the upper Tithonian. The integrated high-resolution sequence-stratigraphy tied to $\delta^{13}C$ chemostratigraphy of the Adriatic Platform provides a framework that can help us better understand and track the environmental and sea-level changes in the tropical Tethys Ocean during the Middle and Late Jurassic.

Seismic stratigraphy of Eocene-Pliocene mixed depositional system on the SE New Zealand continental margin, Great South Basin: Acoustic response, palaeoceanographic and hydrocarbon implications.

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Deeply buried mixed depositional systems have been identified in the Eocene-Oligocene succession of the Great South Basin in southeast New Zealand. This margin is currently affected by energetic flows of baroclinic western boundary currents which are associated with the formation of a contourite depositional system. Extensive analysis of 2D and 3D datasets acquired offshore SE New Zealand have revealed at least eleven drifts of three distinct mixed depositional systems which were formed in the mid-Eocene - late Eocene (onset of drift formation) and to early- late Oligocene (vertical growth stage). These mixed systems have been classified on the basis of their orientation, asymmetry, lateral migration, spatial distribution, and vertical variability of their depositional and erosional features. The depositional evolution of these mixed systems changed in the Oligocene. The mixed system is characterized by a drastic shift in its architecture and gross geometry. Therefore, the change in geometry reflects a weakening of the bottom current system, and a shift of their location during the vertical drift growth stage.

The drifts built within these distinct mixed systems can be distinguished from each other based on their acoustic response, internal stacking patterns, and direction of lateral migration. Furthermore, the changes observed within these drifts and their mixed systems have been linked to variations in continental slope topography, different current systems with conjugate flow directions, and an active subsiding margin (particularly during the Paleogene interval) which led to local fluctuations of the ACC flow and other currents linked to intermediate water masses (SAMW and AAIW). It has been deduced that the Paleogene mixed systems were generated in the New Zealand Basin by intermediate water mass flows, from the Eocene-Oligocene boundary (which are coeval with the opening of the Tasmanian gateway and the inception of east-west flowing ACC) until the late Oligocene.

Ocean current-induced sand accumulation and transport to deep-sea through submarine canyons during the Holocene at offshore of south Kyushu, Japan

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The submarine canyon is an effective sediment (sand) pathway from shelf to deep-sea. Active and continuous sand transport to canyon head plays a crucial role to form thick sand beds in the deep-sea basins. Therefore, it is important to understand outer-shelf to upper-slope sedimentation and its link to sediment transport through the canyon to deep-sea. A typical ocean-current controlled sedimentary system has been developed on the south Kyushu shelf around the Osumi Strait and southeast of Tanegashima Island. Strong Kuroshio Current prevails along the Strait and the upper slope. Fine to very fine sands have been deposited in the distal outer shelf and upper slope above ~300 m water depths. The Naka-Tane Canyon and the Minami-Tane Canyons are submarine canyons east-southeast of Tanegashima Island. Surface sediment and bedform distribution on the outer shelf and upper slope indicates that the distal very fine sands have been accumulated at head of the canyons. Thick (meter-scale) turbidite sand beds were obtained in cores collected at the upper part of the Naka-Tane and Minami-Tane canyons and near the Naka-Tane Canyon mouth. Similar thick turbidite sand beds occurred in the nearby forearc and slope basins. However, no such thick turbidite sand bed found in the other forearc basins far from the Osumi Strait and Tanegashima Island along the south Kyushu slope during the Holocene. Active and continuous sand transport and accumulation near the canyon heads by the Kuroshio Current and collapse and transport of the accumulated sands through the canyons is the most likely mechanism to form thick deep-sea sand beds in the forearc basins during the Holocene.

Some thoughts on the elusive concept of early marine-diagenetic dolomite and its bearing on seawater properties

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Outstanding cases of extensive and stratigraphically thick, marine-dolomitised carbonate platforms are known from the Upper Archean and Proterozoic rock record, and analogues exist in the Palaeozoic and Mesozoic. Indeed, transforming very large volumes of precursor carbonates - immediately after their formation - into dolomite is an exceptional process under Earth's surface conditions. Due to the (early) marine-diagenetic nature of the reactive porewater, these stand apart from carbonate platforms that underwent late-stage, hydrothermal-burial dolomitisation at greater burial depth. Marine porewater dolostones are commonly present as a dense mosaic of fine-crystalline, planar subhedral crystals, herein referred to as 'dolomicrite'. Dolomicrite builds between 50 and 90 % of dolostones of the geological record, depending on the case setting, the source cited and the time interval considered. Many ancient dolomicrites consist of a complex paragenetic succession of (i) pore-filling, primary dolomite cement, (ii) fabric-retentive marine porewater replacement dolomite, (iii) fabric-destructive dolomite and (iv) late-stage, pore-filling dolomite. Hence, 'dolomite' is best used as an umbrella term for a series of Ca-Mg carbonates with different formation histories, compositions, and properties. Numerous studies have exploited geochemical data from fabric-retentive dolostones. Due to their early diagenetic nature and stability throughout geological times, the rationale is that these carbonates represent archives of contemporaneous seawater. The present contribution addresses three questions: First, is early marine-derived dolomite indeed 'early' or better understood as a continuum of processes that commence in a near-seafloor diagenetic environment and extend into hundreds of meters of marine burial? Second, if so, where is the threshold limit to separate marine burial dolomite from non-marine burial dolomite? Third, are marine porewaters at depths of tens to hundreds of meters representative of (recent or past) seawater composition, and, consequently, are marine diagenetic porewater-derived dolomites indeed archives of seawater or represent the precipitating interstitial fluid at the given physicochemical conditions?

Preliminary results in searching for ancient delta deposits on the NW continental shelf of the Black Sea

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Danube Delta is one of the most representative in the world and started to form no earlier than 9000 years BP. Based on previous works published by several authors we assume that other deltaic bodies could be developed on the continental shelf area, south-east of the present submarine Danube Delta. The development of delta deposits on the NW continental shelf of the Black Sea during Quaternary is very much related to the sea level variation. During low level stands the ancient network of rivers, especially corresponding to the paleo-Danube and paleo-Dnieper, when the climate conditions were favorable (that allowed enough water and sediment supply) deltaic bodies should be developed on the continental shelf.
Based on very high resolution seismics (chirp sub-bottom profiling and 2D sparker recording), accompanied by multibeam echosounding and together with gravitational coring we started to search for ancient delta deposits in our area of interest.
Preliminary data showed us many sub-bottom structures as paleo-valleys and sedimentary successions that could be deltaic bodies; these structures are many times close to the sea floor, but also deeper buried at depths of about 40m below the sea bottom. In many cases such sub-bottom structures are accompanied by shallow gas seismic facies, that hinder the deeper seismic horizons. The shallow gas presence indicates a significant input of organic matter that by microbiological decomposition produces biogenic methane and other gases. The information obtained via the detailed analyses of one core shows a very dynamic environment with strata formed by old lacustrine sediments and more recent marine ones.

Coastal consequences of a warming world: Insights from the Paleocene Greenhouse of Arctic Svalbard

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Predicting the impact of the present-day global warming on the world's shorelines is crucial for mapping future coastal hazards. Coastal environments are particularly sensitive to climate change, because the balance in the accumulation, distribution and erosion of nearshore sediments is controlled by various climate-forced parameters, including global eustatic sea level, regional source-to-sink routes, and local storms and floods. Simultaneously, coastal geomorphology and shoreline position are closely linked with local hydrology and vegetation distribution, such as peatlands which are extremely sensitive to climate, humidity and precipitation. As a result, climate change may cause widespread coastal response in the form of shifting shoreline positions, changing landscapes and habitat modification of ecosystems. However, it remains uncertain how, and how much, coastal environments change with changing climate and temperatures in both time and space. Since the impact of global warming on the world's shorelines remains to be seen, analyses of ancient sedimentary archives are vital for understanding climate-forced coastal changes.

For this purpose, the Paleocene-aged, siliciclastic Firkanten Formation in Arctic Svalbard is unique, because it: (i) forms a paralic sedimentary archive that was deposited in climates warmer than, but comparable to, the present day; (ii) contains abundant fossil peat (coal) seams; (iii) represents various coastal landscapes, including beaches, lagoons, barriers, estuaries, deltas and forests; (iv) records frequent shifts in relative sea level and corresponding nearshore hydrology and peat accumulation; and (v) was deposited near the pole, where signals of climate change are amplified.

In this study, we set out to perform ultra-high-resolution facies reconstruction of the Firkanten Formation to: (i) delineate shoreline shifts controlled by sea-level changes; (ii) evaluate how coastal processes, environments and landscapes shift in response to temperature evolution, and aridity and humidity trends; and (iii) identify changes in shoreline geomorphology in response to shifts in paleotopography and vegetation build-up.

Sequence stratigraphy of chalk: Unravelling depositional secrets in fifty shades of grey pelagic carbonates

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Sequence stratigraphic breakdown and interpretation of relative sea level (RSL) changes in chalk successions are challenging, and in many cases deemed impossible. Despite multi-decadal efforts, a conceptual sequence stratigraphic model remains to be developed for this pelagic carbonate, because conventional methods of identifying RSL changes have been developed from consideration of shallow-water carbonate and siliciclastic systems, where unconformities are easier to recognize due to marked facies juxtapositions and environmental shifts. These principles, therefore, are problematic to employ in the deeper-marine pelagic analogues of chalk.

In this study, a new reference for facies-architectural and sequence stratigraphic breakdown of chalk successions is presented, based on an updated depositional model of the Lower Cretaceous (upper Hauterivian – Albian) pelagic and hemipelagic carbonates of the Tuxen and Sola Formations in the Danish Central Graben (DCG), North Sea; one of the oldest chalk successions recorded globally. Recognition of 50 facies, combined with high-resolution correlation of four depositional sequences, calibrated by biostratigraphic and petrophysical wireline-log data, testify to a dynamic Early Cretaceous basin evolution of the DCG, where the combination of tectonism and eustasy exerted marked local depositional controls. The succession was deposited in a relatively deep subphotic setting within the graben, and records c. 20 Myr of transgressive–regressive sequence stratigraphic cycles, including: (i) late Hauterivian – earliest Barremian highstand and differential subsidence during inversion, resulting in aggradation across a westward-dipping ramp; (ii) early Barremian continued inversion causing plateau condensation, sediment bypass and sourcing of gravity flows, followed by basinal lowstand and associated anoxia, and finally late Barremian tectonic quiescence and highstand with deposition of clean reservoir chalk; (iii) latest Barremian lowstand causing filling of local depocenters, interrupted by early Aptian transgression-controlled anoxia during the global Oceanic Anoxic Event 1a; and (iv) late Aptian – earliest Albian lowstand causing local erosion and heightened influx of clay.

Palaeosols as a window to an earliest Jurassic terrestrial tropical ecosystem: an example from the Lower Jurassic of South Carpathians (Romania)

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The transition from Triassic to Jurassic in the low-latitude Pangea was associated with significant intensification of the monsoonal circulation from the Tethys, which was responsible for the delivery of moisture over land, increased precipitation, and development of a lush vegetation cover. The earliest Jurassic was also an anthracolithic interval, with diverse coal-generating vegetation that locally could lead to the development of economically significant coal seams. Although coal genesis and its obvious association with higher plants are fairly well recognised, the interaction between plants and their substratum outside the active mire is less understood. The root systems are commonly preserved as detached from their mother plants, as the preservation potential of the in-situ plants is extremely small. A succession over 70 m thick of the fluvial and overbank deposits of the Hettangian-Sinemurian sequence from the Reșița-Moldova Nouă sedimentary zone (also known as the Reșița Basin), belonging to the Gettic Nappe in South Carpathians (Romania) with exceptionally well-preserved fossil plants with root systems could be used for studying the links between the plants and the soil formation during the Early Jurassic.

The detailed analysis allowed us to distinguish several lithofacies and facies associations of a sand-dominated braided river system with episodic overbank deposition. Within those associations, several palaeosol horizons were identified, which were developed over floodplain deposits or on inactive swamps. The soil shows different stages of development (from immature protosols to more mature vertisol types), commonly with polyphase rooting processes. The topsoil horizons (A/O) are associated with a significant accumulation of well-preserved and highly diverse plant fossils (in Anina, a fossil Lagerstate locality). As such, the relationship between the soil type and the main plant fossils (and indirectly, the palaeoclimate) could be established, providing a unique window to the Mesozoic terrestrial tropical ecosystems.

Unveiling Carbonate build up evolution using Forward Stratigraphic Modeling Approach in the Central Luconia Province, Malaysia

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This study explores the application of forward stratigraphic modeling (FSM) in the context of carbonate reservoir exploration, with a focus on the Central Luconia Province, Malaysia. The Central Luconia Province is known for its extensive carbonate build-ups and serves as a prolific hydrocarbon reservoir. FSM represents a paradigm shift in geological modeling, relying on mathematical representations of physical rules governing transport, and sedimentation in carbonate growth. The study, situated in the EX Field, demonstrates the effectiveness of FSM in replicating the complexities and resulting stratigraphic architecture of the EX-isolated carbonate platform. The methodology integrates parameters from existing literature with multiscale data, incorporating a modified sea level curve and carbonate production laws dependent on water depth. The results showcase the potential of stratigraphic forward modelling in unravelling the complexities of carbonate systems, particularly in regions with prolific hydrocarbon reservoirs like Central Luconia. The incorporation of literature-derived parameters and multiscale data serves as a evidence to the model's ability to provide nuanced insights into the dynamic evolution of carbonate platforms, advancing reservoir prediction and future management strategies.

Global pattern of sedimentary mercury through the Paleocene-Eocene Thermal Maximum: links to volcanism and depositional conditions

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Sedimentary mercury (Hg) concentrations have been widely used to fingerprint geological volcanism. The Paleocene–Eocene Thermal Maximum (PETM) was likely at least in part driven by magmatic activity associated with the North Atlantic Igneous Province (NAIP) based on multiple proxies. Anomalously high sedimentary Hg concentrations have been recorded across the PETM from some locations, supporting this link. Nevertheless, existing PETM Hg data show strong heterogeneity, and may be affected by: the depositional environment, the way Hg is hosted in sediments and rocks, weathering and diagenesis. To more critically evaluate the precise pattern of sedimentary Hg variations across the PETM, and thus validate the efficacy of sedimentary Hg as a volcanism proxy, a compilation of new and existing Hg concentration and associated data across the PETM from 19 globally distributed sedimentary records has been analyzed. Our findings indicate intercontinental sedimentary Hg enrichment ~30 kyr before, and within the onset of the PETM event, supporting significantly increased volcanic Hg release and/or thermogenic Hg release via hydrothermal vent complexes (HTVCs) as the key trigger of the PETM. However, evidence for magmatic activity through the rest of the PETM (which lasted ~200 kyr) is more complex and equivocal, and the available Hg data may be influenced by changes in volcanic activity/style, and/or changes in Hg fluxes from the NAIP. Moreover, our work highlights the importance of depositional environment as a first-order control on sedimentary Hg abundance, something that needs to be considered when using sedimentary Hg as a proxy for paleo-volcanism. In particular, Hg abundance may be significantly influenced by water depth of the depositional site, distance from likely Hg sources, and changes in sedimentation rate.

Stratigraphic controls on fluid flow and retention within marine mudstone successions

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Marine mudstones are the most common sealing lithology for subsurface accumulations of non-aqueous fluids such as hydrocarbon vapors and liquids, carbon dioxide and hydrogen. At the same time, these fluids typically migrate through marine mudstone successions to form naturally occurring accumulations in reservoir lithologies.

The stratigraphic architecture of mudstone successions exerts a primary control on flow and retention of these non-aqueous fluids. Therefore, the description of the three dimensional architecture of mudstone successions is vital to understanding naturally occurring accumulations, as well as governing containment adequacy of injecting fluids into reservoir lithologies, such as is the case for geologic carbon sequestration.

The controlling pore architecture is a function of depositional processes, sediment provenance (including detrital and biogenic components) and post-depositional compaction and cementation, which are fundamentally linked to the original depositional rock fabric and composition.

Sequence stratigraphic descriptions of a variety of marine mudstone successions, spanning geologic ages from Paleozoic to Cenozoic and across a range of tectonostratigraphic basin settings, are shown to demonstrate fundamental controlling factors on flow and retention. Integrated rock, wireline log and seismic workflows are illustrated to describe the controlling architecture.

At the rock fabric scale, a key component of characterization is the quantification of detrital clay mineral aggregate versus silt and sand sized components, as well as an articulation of key biogenic components that make up the rock fabric. Contrary to some paradigms, more distal positions along a depositional profile may not result in increased sealing capacity, as biogenic-rich mudstones may have significant porosity, in addition to being prone to brittle fracturing due to early diagenetic hardening.

At the tectono-stratigraphic scale, thick homogeneous clay-mineral rich deposits may be associated with times of significant aggrading-to-prograding delta clinoforms, as well as basin settings prone to (shelfal or deepwater) contour-current deposition.

Title: Cross-evaporite fluid escape trails along the northern Levant margin: evidence for a leaking petroleum system

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The 2 km-thick succession of Messinian evaporites present above an extensive sedimentary sequence in the northeastern Levant Basin is considered to represent an excellent seal for hydrocarbon reservoirs, CO2 storage, or nuclear waste disposal sites due to its extremely low permeability and thickness. However, the recognition of fluid flow evidence manifested as pipe structures in the supra-evaporite sequences and their spatial distributions in relation to sub-salt structures indicate potential seal failure or fluid leakage through the salt unit. We use high-quality 3D seismic data to characterize the morphology and distribution of the pipes depending on their geometry, terminus, genesis mechanism, and size (width and diameter) through the stratigraphic sequences to reconstruct the fluid migration history. Most of the pipes are rooted in the basal part of the Messinian evaporites and crosscut the whole salt sequence prior to termination in post-Messinian deposits as pockmarks, salt diapirs, or mud volcanoes. It has been interpreted that Late Miocene compression generated an uplift of the Levant margin and played a major role in elevating fluid pressures to critical levels. In addition, gas exsolution from trapped hydrocarbons in sub-salt anticlinal structures triggered hydrofracturing of the salt seal and cross-evaporite fluid migration. Basinward gravity gliding of the salt modified some sequential pipe paths from vertical to tangential trails from the same episodic emission point. We further demonstrate the presence of indicators of petroleum leakage, including gas chimneys, pockmarks, bright spots, and polarity reversal in the vicinity of the pipe structures. Various seismic attributes were performed for structural and stratigraphic interpretation to delineate potential fluid migration pathways from the sub-salt anticlines to the shallow sediments (Plio-Pleistocene) below the seabed.

Genetic Insights of Carbonate Tidal Deltas in the Mishrif Formation, Iraq

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The characterization of underground carbonate reservoirs is challenging because they are more heterogeneous than siliciclastic reservoirs. Overlapping regions between platform interiors and platform margins often develop carbonate tidal deltas, which are formed by the gaps between islands laterally restrict and concentrate tidal currents. The ancient outcrop suggested that the carbonate deltas of tidal origin were either overall mounded geometry with S-shaped slopes or bioclastic lobes with foreset structure. The architectural characterization of these carbonate tidal deltas, however, does not seem supported by modern sedimentary and underground reservoir examples. Recent studies suggest that the composition, geometry, and sedimentary topography formed during the active phase of shallow-isolated platform shoal and tidal delta formation are likely preserved in the stratigraphic record. Three key architectural elements are identified in the Mishrif Formation, Iraq: Flood tidal delta lobes, Ebb tidal delta lobes and non-tidal delta lobes. A three-phase relative sea-level periodic changes history is established related to tidal delta lobes migration, geometries and facies distributions indicate analogs to the modern tidally-influenced tidal delta of the Bahamian platform margins system. The relative sea level lowstand governs the size of the delta, and the relative sea level highstand controls the filing of "Evening up" pattern between flood and ebb tidal delta lobes. The coupling between the inherited landform and net circular hydrodynamics determines both the external shape of crescent-shaped and internal structure of progradation/lateral for the tidal delta lobes. This study will ultimately lead to more effective strategies for inter-well exploitation of the tidal delta reservoirs.

Lithological data reveal persistent eccentricity control on fluvial sedimentation during the Late Pennsylvanian - a case study from the Upper Silesia Coal Basin, Poland

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The short-term variability of Late Paleozoic glaciation, is relatively poorly understood due to discontinuous stratigraphy and limited time control of proximal records of polar climate. Far-field effects recorded in the extensive and well-dated sedimentary successions of low-latitude Pangea can therefore provide potentially useful insight into short-term climate change and help to evaluate the controls on high-latitude glaciation. This study examines a Middle to Late Pennsylvanian (~306-314 Ma) fluvial sedimentation in the Upper Silesia Coal Basin (~2°N paleolatitude) and shows that both coal-bearing and coal-barren fluvial cycles in this equatorial region are predominantly driven by the ~100 kyr cycle of orbital eccentricity. The data suggest a long-term persistence of eccentricity control, which remains stable throughout the onset of Late Pennsylvanian aridification and declining atmospheric CO2 levels. The prominence of eccentricity pacing and suppressed precession-scale variability in the fluvial environment contrasts with the frequency composition of low-latitude seasonal insolation series and published palaeoclimate models. Two theoretical explanations are proposed: (i) an eccentricity component imposed on equatorial climate by far-field feedbacks to glaciation, analogous to the carbon cycle feedback documented from the Pleistocene glacial-interglacial cycles; (ii) local, equatorial seasonal insolation and the effect of semi-annual wet/dry cyclicity in transferring variance from precession-scale insolation changes to the modulating eccentricity term. The latter scenario is decoupled from high-latitude climate and would imply the absence of a far-field tropical response to glaciation. The results of the time series analysis suggest a change in the depth-domain frequencies of fluvial cycles across the boundary of local lithostratigraphic units - the Łaziska and Libiąż Beds – in support of paleobotanical data indicating a prominent hiatus at this level.
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Sedimentary responses to extreme warming: insights from the geological record

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Understanding the responses and sensitivity of the global hydrological cycle to rising atmospheric CO_2 and temperature at the present day is a key challenge. Climate warming (and consequent increase in atmospheric water storage) is predicted to lead to large-scale but spatially variable changes in hydroclimate, with corresponding impacts on sedimentary systems. Observational data obtained over the last few decades have revealed increased frequency of intense tropical cyclones in some regions, increased fluvial sediment loading, and elevated occurrences globally of precipitation and drought extremes. The magnitude and pace of these changes may be unprecedented, but similar hydroclimate changes occurred during deep-time hyperthermal events. These events, such as the Paleocene-Eocene thermal maximum (PETM, ~56 Ma) and Toarcian oceanic anoxic event (T-OAE, ~183 Ma), were characterised by marked but transient (<1 Myr) increases in atmospheric CO¬2 and global temperature. Known changes in hydroclimate across hyperthermals include increased chemical weathering, elevated freshwater runoff and terrigenous sediment fluxes, and intensified storm activity. Nevertheless, key knowledge gaps exist regarding the magnitude, spatial pattern and mechanisms of these changes. Concentrating primarily on the PETM and T-OAE, I review the geological evidence for hydroclimate changes during extreme warming, and discuss their impact on the sedimentary record. Sediment supply changes were a key characteristic of both the PETM and T-OAE, but the links between sediment supply and climate were complex and spatially variable. Evidence for enhanced storm activity is prevalent across the T-OAE, but not the PETM. Notably, extensive tempestite deposition during the T-OAE is consistent with climate model predictions of increased tropical cyclone intensity and a poleward shift in storm tracks under elevated atmospheric CO_2. Together, the findings help demonstrate the utility of deep-time hyperthermals as potentially useful analogues for the changes in weather and hydrology expected with continued anthropogenic warming.

Spatial variability in meander characteristics within modern Distributive Fluvial Systems (DFS)

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Fluvial systems support a large variety of habitats, are important biogeochemical interfaces and act as conduits for delivering sediment and water to seas and oceans, as well as forming political boundaries. Fluvial sandstone deposits have the potential to act as reservoirs for carbon capture and storage, and form the basis of geothermal and freshwater aquifers. Therefore, understanding the lithological variation and connectivity of such deposits is critical to enhancing natural resource exploration and the sequestration of carbon for our atmosphere.
Recent research suggests that the abundance of subsurface fluvial deposits, such as meander deposits, have been significantly under-estimated in within sedimentary basins. Therefore, meander deposits may form a bigger proportion of the rock record than previously thought. Research is required to better understand the spatial variation in gross-scale meander system characteristics, such as deposit architecture and connectivity. Understanding small-scale characteristics such as porosity and permeability is also of importance, as these variables are primary influencers on how subsurface fluids flow and convey pollutants.
This project aims to bridge these knowledge gaps by studying both modern and ancient meander deposits within a spatial context, by exploring how both gross-scale and micro-scale characteristics vary within and across several sedimentary basin types within different climatic settings. This will provide new quantification of the spatial variability expected within subsurface deposits, and give an insight into modern fluvial geomorphic processes. Results from the Wood River DFS, Alaska, indicate how meander characteristics (e.g. meander sinuosity, amplitude and migration rate) vary downstream within a modern DFS, and comparison with the Bermejo DFS, Argentina will indicate how these compare to a different geographical and basin setting.

Are turbidity currents super- or subcritical in meandering slope channels?

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The current consensus is that turbidity currents in slope channels are either supercritical or alternate between super- and subcritical states as they traverse cyclic steps. However, it has been argued that on the lower gradients of the slope and rise, the long run-out of turbidity currents is indicative of negligible entrainment, and thus of subcritical flow.

Bulk Richardson (or Froude) numbers are often used as indicators of the degree of entrainment of ambient water, and therefore as a measure of the stability of the stratification of the current. This is problematic, since Froude numbers of unity do not necessarily correspond to critical values of gradient Richardson number, the true determinant of stability. Moreover, specific energy arguments imply that the critical Froude number may not be unity.

The nature of flows in sinuous channels has been debated, with various authors arguing for 'normal' (i.e. river-like) or reversed secondary circulation, or paired circulation cells, assuming a progressive vertical density gradient in the flows. Over the last few decades, there has been increasing recognition of meander belts in slope channel systems, both in the subsurface and at outcrop, with true point-bar development.

Recent direct numerical simulations suggest the existence of two radically different flow states: 'supercritical', with vigorous mixing due to instabilities, and a progressive vertical density decrease; and 'subcritical' state, with a lower, fully turbulent and more or less uniform layer, separated from a weakly or non-turbulent much more dilute upper layer across a steep density gradient. Significantly, the lower layer behaves similarly to an open-channel flow. It is suggested here that meandering channels form under this 'subcritical' state, and the thickness of the lower layer is the determinant of channel depth. The dilute nature of the upper layer means that relatively little overbank sedimentation should occur under these conditions.

Distribution of fluvio-aeolian deposits of the Middle Buntsandstein Group, Lower Triassic, Upper Rhine Graben (NE France)

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The Lower Triassic succession of the German Basin has been analysed in the Vosges Mountains (France), Palatinate Forest (Germany), and in subsurface of the Upper Rhine Graben (URG). The occurrence of these deposits allows sedimentological and architectural analysis with significant lateral correlation of continental sandstones and conglomerates over c. 2,500 Km^2, with a high level of confidence; thus, favouring the palaeoenvironmental reconstruction of the Lower Triassic's Scythian cycle in the German Basin. The aim of this project is to characterise the depositional environment of the Upper Grès Vosgien and Conglomérat Principal Formations, and to reconstruct the distribution of the fluvial-aeolian deposits. Outcrops of these units in the western shoulder of the URG, and core samples from a geothermal well in the URG, were described using facies, architectural analysis, and palaeocurrents measurement. The Upper Grès Vosgien Fm. Is characterised by the interfingering of aeolian and fluvial deposits. The fluvial deposits are composed of interbedded trough and sigmoidal cross-stratified sandstones, gravelly sandstones, and bounded by erosional and horizontal surfaces between sets. The aeolian deposits are represented by moderately- to well-sorted, fine- to medium-grained sandstones, with low-angle cross-lamination, wavy and crinkle lamination, aeolian dunes, and deflation lags. In the northern part of the study area, the aeolian facies beds range between 60 and 550 cm in thickness, versus c. 25 to 55 cm in the southern part. Fluvial facies are recorded in layers ranging between c. 25 and 150 cm in thickness in the entire study area. The Conglomérat Principal Fm. marks an abrupt change in the depositional pattern, with conglomerates eroding into the Upper Grès Vosgien Fm. deposits, potentially representing a pulse of fluvial sedimentation, or an adjacent braided system. The sedimentological and stratigraphic properties reflect the palaeoenvironmental and palaeoclimatic conditions of formation of the Middle Buntsandstein fluvial-aeolian deposits.

History of diagenesis of the Middle Jurassic sideritic rocks in Poland

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Sideritic rocks were tested from 52 boreholes in the Polish Lowlands, in the north-eastern margin of the Holy Cross Mountains, and in the Częstochowa region. Sideritic rocks are represented by clayey siderites, sideritic sandstones and sideritic coquinas. Sideritic conglomerates and sideritic claystones and mudstones are less common. Sideritic rocks occur in the form of layers and concretions. Siderites were formed mainly in Lower Aalenian, Lower and Upper Bajocian, Lower and Middle Bathonian deposits. Sideritic rocks are composed of iron carbonate, mainly Mg-siderite (sideroplesite and pistomesite) and less frequent siderite. They are accompanied by varying amounts of clay minerals, mainly berthierine, kaolinite, illite, and locally chlorites and other carbonate minerals such as: calcite and ankerite. Iron carbonates are represented by micrite, microspar and spar. Mg-siderites form in places rhombohedral crystals that are often characterized by a zonal structure, with a distinct enrichment in magnesium in their outer parts, compared to the middle part that is richer in iron. Berthierine occurs commonly in the form of ooids or a cement, and it fills the interior of bioclasts. In the history of diagenesis of sideritic rocks, during eodiagenesis, the earliest iron mineral to be formed was berthierine. It was formed under suboxic conditions where iron-containing freshwater mixed with seawater at a temperature of about 25-45ºC. Then, under anoxic or suboxic conditions, in the microbial methanogenesis zone, probably at a temperature of about 20°C, sideroplesite and siderite crystallized either from pore water of marine origin or from seawater that mixed with freshwater. At a later stage of diagenesis (mesodiagenesis), the following temporal sequence took place: sideroplesite (containing a higher amount of magnesium) and pistomesite crystallized at a temperature of above 60ºC, and calcite and ankerite crystallized at temperatures of about 60°C and about 70-160°C.

The challenge of exploring tsunami deposits in zones vulnerable to multiple extreme sea wave events

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The identification of paleotsunami deposits in zones of high seismicity and subject to extreme ocean wave events is a complex issue. It must consider many aspects such as historical earthquake-tsunamis, storms, high tides, vertical movement of coastal morphology, sea level change records, and anthropogenic activities. The problem becomes more intricate when the height and inundation distance of tsunami waves are lower than storm waves. Therefore, this study will expose the challenges and solutions in the investigation of paleotsunami deposits in coastal areas with complex morphological dynamics. The methods used in this study include numerical modeling of run-up height and tsunami wave propagation, highest tide and storm wave analysis, shoreline change analysis, core and trench observations on the southern coast of Sicily, and granulometric analysis of sediments suspected as paleotsunami deposits. The results indicate that the inundation distance of tsunami waves from the shoreline is not always farther than high tides or storm waves. Tsunami wave propagation is highly influenced by earthquake magnitude, coastal distance from the epicenter, and coastal morphology. There are no specific characteristics that reliably distinguish between tsunami and storm deposits. However, the time interval of tsunami waves is longer than storm waves and high tides. This study concludes that the recurrence time interval is the most important parameter in discriminating between tsunami waves and non-tsunami extreme ocean waves.

ENIGMATIC DIAGENETIC STRUCTURES OF THE HAUSHI-HUQF HIGH, CENTRAL OMAN

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This research focuses on enigmatic structures of suspected Cambrian age unit (Lower Paleozoic Haima Supergroup) of the Haushi-Huqf High, Central Oman. Covering ~1 km2, the study area is on a horst-block bounded by north-south oriented faults. This exposure surface reveals spectacular 10's to 100's m-scale concentric, nested/coalescing ring-like structures within a siliciclastic deposit. These structures form regularly spaced concentric crest with lateral heights of several meters bounded by wide troughs. Establishing the stratigraphic position of the unit is challenging, owing to the paucity of datable material. U-Pb Zircon dating of the host sediment does however reveal two populations: 2.8-2.5 Ga., likely sourced from Precambrian rocks of Yemen, and ~530 Ma., corresponding to Cambrian igneous units proximal to the site. Based upon the latter, Lower Paleozoic origin is likely. Those deposits are composed of fluvio-deltaic quartz arenite, which also contain bioturbations within select intervals, indicating marine influence. Furthermore, a thin deposit of botryoidal calcite within the bedding is observed, suggesting possible microbially induced precipitates of carbonates, signifying potential microbial activity during deposition. Petrographic analysis reveals a strong diagenetic control in the structures. Samples from the crests exhibit strong compaction and cementation reducing porosity via interlocking quartz overgrowths. Conversely, the rocks from the troughs are generally porous and poorly consolidated, and with the presence of bioturbation and calcite cementation. The contrasting competence rocks forming the topographic highs and lows resulting in the remarkable architecture observed therein. We suggest that spatially disparate early carbonate cementation associated with microbial activity shielded the pore system from pervasive silica cementation and compaction. The pronounced spatial organization of calcite precipitation and cementation controlling these diagenetic structures poses compelling questions relating to the self-organization of microbial cover during the Cambrian substrate evolution, hinting at the presence of internal spatial feedback and environmental controls in their nucleation and propagation.

Oxfordian megastromatolites from Central Dobrogea, Romania

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Carbonate deposits from Central Dobrogea are well known as part of the European Upper Jurassic sponge-microbial megafacies. Previous detailed studies indicate deposition of these carbonate buildups on a gently westward deepening homoclinal ramp. The 150-170 m thick Cechirgea Member in the middle to uppermost Oxfordian Casimcea Formation contains giant stromatolites, here termed megastromatolites. These domal and cylindrical to conical structures up to 3 m in height contain irregular sinusoidal macrostructures up to 0.5 m in amplitude and 0.2 m in length, together with draped sedimentary wedges on the flanks of the domical stromatolites.

Several domes and cones have steep, almost vertical flanks. The mesostructure ranges from planar to crinkle laminated. The layers consist of sheets of continuous laminae in which dark (grey or ferruginous) dense micritic laminae, up to 2 mm thick, alternate with millimetric microspar laminae 3 to 5 mm thick. Commonly the laminae form 0.2–10 cm wide contorted folds that show “roll-up” structure. These deposits contain hexactinellid and lithistid sponges, bivalves, brachiopods, serpulid worm-tubes, rare bryozoans, thecideid brachiopods, belemnites, ammonites and abundant encrusting Crescentiella morronensis. Overall, these Oxfordian megastromatolites from Central Dobrogea with complex and distinctive hybrid fabrics resemble Proterozoic cylindroid stromatolites with nested conical laminae. These megabuildups appear to have formed in conditions with reduced sedimentation rates. Their morphology was likely influenced by the interplay between accretionary growth and water movement.

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Geomorphology and sedimentology of a rapidly retreating Alpine glacier: insights from the Taschachferner, Tirol, Austria

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The rapid retreat, demise, and even collapse of Alpine glaciers is widely reported as humanity grapples with dramatic climate change in mountainous regions. Alpine glacier forefields offer a wide spectrum of settings through which the ancient sedimentary record can be interpreted. Glacial valley orientation, bedrock slope and lithology, and plumbing of subglacial and englacial meltwater drainage all influence the immediate preservation potential of glacial sediments upon deposition. In this contribution, we explore the geomorphology and sedimentology of the Taschachferner, presenting a new geological-geomorphological map. This small glacier drains an icefield in the Ötztal Alps, and its current ice margin lies at approximately 2550 m a.s.l. Thus far, the glacial sedimentology and its bedrock geology have not been subject to investigation. The bedrock geology is dominated by E-W striking units of paragneiss and amphibolite of the so-called “Bunteserie”, and the latter exhibit a series of well-preserved striations together with meltwater-sculpted bedforms (p-forms). The lower region of the glacier can be divided into two parts: (i) a clean-ice part, on the northern valley side with a low, subdued profile and (ii) a debris-covered part at the southern valley side, covered with supraglacial debris. The valley margins are dominated by several generations of lateral moraines, the most prominent of which corresponds to the 1852 Little Ice Age Maximum. A well-developed “hanging sandur” is observed immediately in front of the ice margin. This consists of a series of sand and gravel bars cradled in the lee of an interpreted regional fault cross-cutting the bedrock. Sandur deposition is currently influenced and overprinted by dead ice, influencing the trajectory and location of river channels and gravel bars. The Taschachferner provides clear lessons regarding the distribution of ice-margin facies associations, which must be incorporated into models of glacier decay in the context of a rapidly warning climate.

The earliest stromatoporoid reefs and the Great Ordovician Biodiversification Event

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The Great Ordovician Biodiversification Event (GOBE) significantly impacted reef evolution, marked by the abrupt emergence of stromatoporoids, corals, and bryozoans within the global reef ecosystem during the late Darriwilian (late Middle Ordovician). It has been suggested that the evolution of reef-building organisms was hindered in the Early Ordovician due to high temperatures and a consequent decline in dissolved oxygen in seawater, which would have been resolved by the late Darriwilian. Here, we report the earliest stromatoporoid-dominated reefs in the upper Tremadocian (Lower Ordovician) of South China. These reefs were primarily constructed by stromatoporoids, alongside the calcimicrobe <i>Girvanella</i>, stalked echinoderms, and lithistid sponges. Stromatoporoids played a crucial role in binding and structuring the complex reef community, providing a habitat for various organisms. In contrast to other palaeocontinents where microbial carbonates, lithistid sponges, and calathiids dominated the Early Ordovician reef ecosystem, South China exhibited a prelude to newly appeared metazoan reef builders, including stromatoporoids and bryozoans. We hypothesis that South China was a locus of biodiversification during this period. These newly appeared reef builders in South China likely expanded globally during the late Darriwilian when environmental conditions became more favourable for metazoan reef builders to thrive.

Seismic expression of two scales of clinoforms in the Schrader Bluff and Canning formations, Colville Basin, North Slope, Alaska, USA

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The sequence stratigraphic framework of a part of the Brookian sequence on the North Slope (Alaska, USA) of Maastrichtian age is presented. We describe two scales of clinoform progradation and provide insights into the depositional environment distribution in the area.
The Northern Colville Basin of Northern Alaska developed as a foreland basin created by the rise of the Brooks Range orogen with a progressive infill throughout the Cretaceous and Paleocene. This Brookian Sequence is a non-marine to deep marine clinoformal sequence that prograded from the west-southwest towards the east-northeast, filling the western two thirds of the Colville Basin. The Schrader Bluff, Canning and Hue Shale formations, presented here, represent respectively the shallow marine, slope, and deep-water deposits of this shelf-to-deep-marine clinoformal sequence during the Campanian to Early Paleocene.
This Maastrichtian succession was subdivided into three third order clinoformal sequences based on a combination of high-resolution 3D seismic volumes, well logs, core descriptions and literature. Inside the Schrader Bluff Formation smaller scale deltaic clinoforms are observable prograding inside the HST and LST while current-reworked deposits are observed in the TST.
Seismic imaging allows for interpretation of the interval and shows several features of interest such as slump-scars in the shelf edge, MTC deposits associated with these scars, reworked transgressive deposits that can be amalgamated with regressive deltaic deposits and slope deposits that indicate the presence at times of strong bypass of sediments through the shelf.
Amplitude and spectral decomposition maps can be used to determine deltaic style (and therefore the likely process domination at the coastline), and its change depending on the position of the deltaic clinoform with respect to the shelf edge. It can be seen passing from lobate away from the shelf-edge to linear near the shelf edge, perhaps indicating a change towards more wave influence in the delta.

Response of the Pearl River evolution to the topographic changes in East Asia: Insights from the detrital zircon provenance

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The Pearl River, which flows from the SE Tibetan Plateau across the South China Block and into the northern South China Sea, holds the key to understanding how tectonically driven surface uplift may have triggered the drainage evolution in East Asia. However, debate continues concerning the evolutionary history of the Pearl River, due to the lack of continuous and entire depositional records. Here we use a quantitative approach based on zircon U-Pb ages for estimating the relative contributions of potential source areas to Cretaceous-modern Pearl River Mouth Basin (PRMB) to constrain the evolution of the Pearl River, and use the Eu/Eu* anomalies in zircon to reconstruct the crustal thickness of the South China margin and Tibetan Plateau. Our findings reveal that four provenance changes occurred in the PRMB from the Cretaceous to the present day, which one was caused by the rifting of the continental margin and three were caused by the drainage evolution. In accordance with the provenance history, the evolution of the Pearl River is divided into three stages, i.e., the late Cretaceous initiation of the eastern tributaries, the Paleocene-late Eocene initiation of the northern tributaries, and the early Miocene initiation of the western tributaries. The initiation of the eastern tributaries is likely triggered by the uplift of the Coastal Mountains following the Western Pacific subduction, while the initiation of the western tributaries is likely triggered by the uplift of the Tibetan Plateau following the India-Asia collision.

Climate-driven sedimentary change in the Middle Pleistocene, Corinth Rift

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The drill sites of IODP Expedition 381 captured a long and continuous sedimentation record in the center of the Gulf of Corinth, one of the fast-extensive rifts on the earth, showing primarily calcite rich, fine-grained, distal sediment gravity flow and hemipelagic deposits. The deposits show a clear link to climate-driven changes of environment and sedimentary process during the glacial and interglacial periods. During glacial periods (I, III, V), intense physical weathering and erosion of source rocks due to open vegetation, which provided adequate sediments into the basin causing higher sedimentation rates. Decrease of atmospheric pCO2 and erosion of terrestrial carbonate clasts from the Mesozoic carbonates on shore induced positive excursion of 13C and precipitation of calcites. Frequent turbidity currents were developed by seasonal floods. During the interglacial periods (II, IV, VI, and VIII), warm and humid climate enhanced chemical weathering onshore indicated by high content of Ti, Al, Fe, and Mn. However, forest landscape constrained physical weathering and source-rock erosion, resulting in lower sedimentation rates by uniform suspension dominated transportation with dilute turbidities. Large volume of freshwater input drove negative incursions of 18O. In the marine stages (VI and VIII, early MIS13) during interglacial periods, microbial bloom on the sea floor enhanced Mn precipitation and intensity of bioturbation. The transitional periods (VII) between marine (interglacial) an isolated (glacial) were commonly under brackish water conditions indicated by thriving of Teichichnuns. Aragonite whitings were highly precipitated by incorporation of riverine Sr and significant decrease of Mg/Ca ratios, which possibly represent seasonal varve products. The IODP expedition 381 illustrates sedimentary change in early history of the last rift phase since ca 0.8 Ma in the Corinth Rift, providing an insight into change of sedimentary environment and filling processes for continental margin rifts which were isolated, partly or fully connected to open ocean.

Carbonate-rich megabeds within a Triassic siliciclastic deep-water system, West Qinling orogenic belt, Central China: Character, processes and implications

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Deep-water megabeds, a particular type of sediment gravity flow deposit, have been widely reported from pure siliciclastic or calciclastic systems. Rarely documented are carbonate-rich megabeds embedded in siliciclastic deep-water systems. Here, we report such a system from outcrops of the Lower Triassic of the northern West Qinling orogenic belt, central China, with a focus on the character, processes, and implications of the carbonate-rich megabeds. The megabeds are thick (1 to 10 m) compared to adjacent beds (commonly less than 1 m), and are of mixed composition, comprising both siliciclastic grains and shallow-water carbonate clasts. These megabeds are commonly characterized by distinctive bipartite or tripartite vertical sequences. A complete (tripartite) megabed consists of a basal clast-supported conglomeratic division (Division I), an intermediate matrix-supported conglomeratic division (Division II), and an upper normally graded and/or laminated sandy division (Division III). These divisions are interpreted to be deposited respectively from hyperconcentrated flows, debris flows and turbidity currents of a single flow event, and record debris flow transitioning to (and outrun by) hyperconcentrated flow, and subsequently transitioning from debris flow to turbidity currents, as a result of progressive flow dilution. Based on regional geology and characteristics of the encasing siliciclastic turbidites and in-situ micritic limestones, these megabeds are inferred to be deposited at a base of slope setting. This study shows that megabeds can show variability in terms of vertical organization (single-layer, bipartite or tripartite) and thickness over a small area, and it is therefore probably misleading to link a particular internal organization of event bes to a specific paleogeographic setting. In this study, we proposed a new depositional model, with frequent longitudinal turbidity current deposition and episodic transverse carbonate-rich megaflow deposition in an elongate basin, for the mixed deep-marine deposits.

Research and application of gravity flow sedimentary reservoir prediction technology in the middle third member of the Eocene Shahejie Formation in Niuzhuang Area

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The gravity flow sand body in fault basin has various genetic types. The complex seismic response characteristics of this type of reservoir are determined by rapid facies transition, small sedimentary scale, complex formation mechanism and distribution pattern.The study analyses the quality of 3D seismic data and selects the seismic data that suitable for target processing. Seismic response characteristics of oil shale in the fourth member of the Eocene Shahejie Formation and multi-well calibration of positive and negative polar wavelets are used to analyse the seismic polarity, which provides a basis for target processing. According to the development characteristics of turbidite sand body and its geophysical response in the middle third member of the Eocene Shahejie Formation, the theoretical and practical forward models of different sand body combinations are designed. By selecting different frequency wavelets to complete the forward experiment, the reasonable parameters will be determined to complete the 3-parameter wavelet high-resolution target processing method, showing remarkable results.The following conclusions are obtained: (1) High-frequency components of processed seismic data are obviously broadened compared to old data, composite wave decomposition is achieved, wave group characteristics are distinct, and synthetic record calibration also shows that processed data are obviously better than original pure wave data;(2) After processing, the continuity of the data wave group is improved and the energy relationship is clear, which helps to identify turbidite sand and other lithology; (3) Multi-well calibration establishes the fine structure model and well constraint model to complete the seismic inversion, and the results agree well with actual drilling. Using techniques in seismic sedimentology such as stratal slice and 90° phase shift to identify the vertical development and plane distribution of the target horizon.This research provides a new idea for the fine characterization of gravity-flow sandstone reservoir in fault basin.

Typhoon Chan-Hom (2015) induced sediment cross-shore transport in the mud depo-center of the East China Sea inner shelf

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The erosion, transport, and deposition processes of sediments that are influenced by typhoons are significant constituents of the sedimentary source-sink processes in marginal seas. Nevertheless, the genesis of storm deposit layers in the continental shelf and their subsequent development and preservation after typhoons have not been comprehensively investigated. In this study, we have conducted a systematic investigation of the processes related to sediment transport and deposition, which were primarily induced by Typhoon Chan-Hom, and analyzed the evolution and preservation of storm deposits utilizing grain-size analysis, radionuclides (137Cs, 210Pbex and 7Be), and organic geochemistry (TOC, TN and δ13C). The 137Cs, 210Pbex, and 7Be inventories of surface sediment and total 210Pb inventory of short sediment cores measured three days after the typhoon suggest that the sediments in the water depth <30 m were eroded, resuspended, and then transported offshore to deposit in the deeper areas (water depth >50 m) of the Mud Depocenter of Zhejiang-Fujian Coast (MDC-ZFC), resulting in the formation of significant storm deposits with high 210Pbex and 7Be. In addition to sediment transport, the offshore area also received organic matter generated by typhoon-induced phytoplankton blooms. Hence, in the present study area, the features of marine organic matter that possess high total organic carbon (TOC) content (>0.4%), low carbon to nitrogen (C/N) ratio (<7.5), and high δ13C value (>-22‰) are crucial for identifying the storm deposit formed by cross-shore sediment transportation. Furthermore, the radionuclides and organic geochemical signals of the sediments revealed that no significant disturbance or transport of the storm sediments occurred three weeks after the passage of Typhoon Chan-Hom due to the high water depth, indicating that these storm deposits could be effectively preserved in this area. This study provides a valuable basis and reference for accurately identifying and interpreting typhoon sedimentary records in the MDC-ZFC.

Heterogeneity and sedimentary characteristics of shale laminae of fine-grained sediments in alkaline lacustrine, Permian Fengcheng Formation, Mahu Sag, NW China

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The heterogeneity and sedimentary characteristics of millimeter-scale laminae in alkaline lacustrine strata of the Fengcheng Formation (P1f2) in the Mahu Sag were investigated using core and thin section observation, geochemical and elemental analysis, mineral identification, and pore examination. Five types of laminae were distinguished, with different mineral composition, pore characteristic and distributions. These laminae occur in four distinct combinations. The pore systems predominantly consist of inter-crystalline pores, intragranular pores, and dissolution pores of feldspar and dolomite, and also contain im-porous alkaline mineral particles. Influenced by variations in salinity, influx of volcanic-hydrothermal material, and the participation of both endogenous and exogenous materials, the formation has gone through five stages of sedimentary evolution. Furthermore, FQL, DOL/RL/SL, and CL is developed in single-terrestrial-sourced still water deposition, hybrid source still water deposition, and single intra source deposition, respectively. Vertically, FQL-DOL combination, performs favorable reservoir characteristics, is the most extensively developed lamina combination in the Fengcheng Formation that primarily developed in the period of the late P1f1, the early P1f2, the late P1f2 and the early P1f3. FQL-RL/SL combination primarily developed in the period of the middle P1f2 and DOL-CL combination is the counterpart in the period of the early P1f2 and the late P1f2 stages. Considering this in conjunction with the longitudinal distribution of lamina combinations, a model is proposed for the distribution of fine-grained sediments in alkaline lacustrine strata that will provide a sound theoretical basis for shale oil exploration and development.

Chemofacies characterization of lacustrine shale based on machine learning classification: A case study from the Dongying Depression, Bohai Bay Basin, China

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The rapid lithofacies transitions and compositional heterogeneities inherent in lacustrine shale posed significant challenges to accurately characterizing it, thus impeding the optimization of shale oil exploration and extraction. This study employed a multifaceted methodology to address these obstacles, integrating principal component analysis (PCA), K-means clustering, and geochemical trend analysis to precisely identify and characterize nine distinct chemofacies. A comprehensive analysis of petrological characteristics and depositional environments was accomplished by examining core samples, thin sections, scanning electron microscopy (SEM), mineralogical compositions, and total organic carbon (TOC) content. The identification of favorable locations was supported by meticulously considering variables, including TOC, porosity, permeability, and the mineral brittleness index (MBI). This investigation revealed the presence of nine distinct chemofacies within the targeted layer. Specifically, Chemofacies 5, characterized by calcite vein laminations, was identified within Unit 2 parasequence, and Chemofacies 6, enriched with feldspar-quartz mineral laminations, was located within Unit 4 parasequence. Both chemofacies exhibited elevated TOC, enhanced porosity and permeability, and favorable brittleness, qualifying them as ideal sweet spots for shale oil exploration. The insights from this study align with the characteristics of traditionally optimal reservoirs, validate the robustness of the employed methodologies, and carry significant implications for the accurate prediction of terrestrial shale oil sweet spots in future explorations.

The Carnian Pluvial Episode(late Triassic) in northeastern Tethys: Lacustrine sedimentary records,petroleum geological significance from the Yanchang Formation,Ordos Basin, central China

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The Carnian Pluvial Episode (CPE) is among the most remarkable climate abrupt event registered on earth. The CPE is characterized by abrupt changes in climate with consequences in depositional environments, source rocks, and hydrocarbon accumulation in lake basins. The case study deals with the Triassic Yanchang Formation in the Ordos Basin, a major onshore petroliferous basin in China. The analysis of global palaeoclimatic changes through outcrop and core observation, lab tests, and seismic interpretation, allow to review the sedimentation and hydrocarbon habitats of the Yanchang Formation. After this study, five conclusions have been achieved.

(1) The significance of the CPE in the Yanchang Formation was stablished. At the boundary between Chang 7 and Chang 8, a sudden facies change was found, which was related to the CPE event. Chang 7 black shales are considered the sedimentary response of CPE event.

(2) Three palaeoclimatic conditions were recognized: arid (Ladinian), warm-humid (Carnian), and semiarid-subhumid (Norian-Rhaetian).

(3) During the Carnian Age and CPE, the lake basin experienced a rapid transgression followed by a slow fluctuating regression characterized by periodic lake water concentration, flourishing organisms, high organic productivity, small consumption, and weak diluting effects, which may have facilitated the accumulation of organic rich source rocks.

(4) Ladinian and Norian-Rhaetian Ages were characterized by a relatively arid palaeoclimate, with limited precipitation and seasonal rainstorms developed before and after the CPE. In consequence, flood events dominated the occurrence and distribution of large-scale sands in central basin areas.

(5) Owing to the influence of the CPE and abrupt changes in palaeoclimate before and after the episode, two xenoconformities turned up vertically inside the Yanchang Formation and dominated lithologic-stratigraphic traps and hydrocarbon distribution. This study fills a gap in understanding the sedimentary response of the CPE in the Pangea at the east margin of the Paleo-Tethys.

Neoproterozoic dissolved organic carbon reservoir

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The amount of carbon in the modern-ocean dissolved organic carbon (DOC) pool is roughly equal to that of the atmospheric CO2, strongly impacting global climate and C cycle. In contrast, multiple lines of evidence suggest that the size of the DOC pool was substantially larger in the Neoproterozoic oceans, although strong debates remain. The formation and contraction of this large oceanic DOC reservoir may have been controlled by complex interactions among atmosphere, continent, ocean and life system in the Neoproterozoic. Evolution of this large DOC reservoir may have further taken or contributed to a series of environmental and life effects, such as large fluctuations in climate (e.g., global cooling and warming) and C cycling (e.g., large sedimentary C-isotope excursions), strong impacts on dolomite deposition (i.e., the “dolomite problem”), and early animal evolution etc. In this talk, I review the evidence and debates for the existence of this large DOC reservoir in the Neoproterozoic oceans, and explore the possible mechanisms for its origin and contraction as well as its possible biogeochemical effects based on latest studies. Finally, perspectives in future research on Neoproterozoic DOC reservoir are provided.

Study on the matching relationship between Permian volcanic activity and Ordovician carbonate karst reservoir in Tarim Basin

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The Ordovician carbonate karst in the study area is affected by atmospheric freshwater and hydrothermal fluid. The Permian magmatic activity was accompanied by large-scale hydrothermal activity, and its hydrothermal karstification has been confirmed in the outcrop area, Tazhong, Tadong, Yingmaii, Tahe, Halahatang and other areas. In the study area, a wide range of volcanic activity developed in the Permian. There are large volcanic intrusions in the west, and the thickness of the Permian volcanic rocks is huge, so enough supply of magma and lava channel and hydrothermal must be available to have an impact on the Ordovician reservoir. Based on the three-dimensional seismic data, the thickness of the Permian volcanic rocks and the paleogeomorphology at the end of the eruption in the study area were analyzed. By analyzing the characteristics of regional fault activity, the distribution of volcanic channels in the study area is comprehensively judged through seismic fine interpretation, seismic stratigraphic slice analysis, drilling logging data, and core analysis. And the fine description of the volcanic channels formed in the Permian was completed. The results show that there are many types of eruption modes and magma channels in the study area, and four types of eruptions are summarized: central eruption, fissure eruption, magma intrusion zone, and underground karst cavity eruption. The fissure eruption mainly rises along the NW-trending fault during the Hercynian movement period. The probability of paleokarst being destroyed in the late Caledonian period is large. And the actual drilling situation also proves this phenomenon. The seismic facies of paleokarst in Ordovician near the central eruption are different from ordinary karst. The drilling results of the paleokarst reservoir which the disc-shaped intrusive rocks pass through show the existence of glass debris, indicating that magmatic activity can directly affect the paleokarst reservoir.

The role of weak layers in the emplacement of carbonate megaslides

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Submarine landslides can destroy seabed infrastructure and generate enormous tsunamis, hence posing a threat to coastal communities. Calcareous ooze is the most widespread deep-sea lithology in the global ocean, and comprises > 50% of seafloor sediments. Although several studies have pointed out the significance of landslides, very little is known about the physical properties of carbonate weak layers at the base of landslides, and their role in pre-conditioning successions prone to failure.

Here, we show the physical properties of the weak layer before and after failure based on 3D seismic reflection data and ODP well logs. Multiple carbonate landslides are widely developed offshore northeast Australia, and the basal shear surfaces of most of them are in the same stratigraphic surface. A weak layer, identified beneath the basal shear surface, comprises a ~ 5 m thick calcareous ooze, underlying an unconformity. The layer is characterized by high water content, high porosity, and low bulk density in the ODP 762 site, where sediments were not disturbed by failure. In comparison, the weak layer in ODP763 where it is the basal shear zone to submarine landslides, is marked by a sharp decrease in water content and porosity, and an increase in bulk density.

The results indicate that the carbonate weak layer preserves the pore water and accumulates excess pore pressures, thus aiding the formation of submarine megaslides even on very gentle (< 2°) slopes. The interaction process between the submarine landslides and the underlying weak layer is suggested to be contractive shear, based on the marked change of physical properties, and the lack of erosion or deformation phenomenon in the weak layer. Hence, the physical properties of weak layers should be considered in future studies to improve slope stability assessment.

High-resolution OSL-dated sequence stratigraphic analysis reveals unexposed bounding surface within multi-order transgressive cycles: an example from the late Quaternary tidal flat sediment cores, SW Korea

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Stratigraphic architecture and sequence stratigraphic framework of fluvio-tidal deposits have attracted much attention of many workers, as they provide a powerful predictive tool of changes in relative sea-levels. Previous studies showed that the late Quaternary tidal deposits in the west coast of Korean peninsular form two 4th-order depositional sequences (sequence I and II) bounded by oxidized gravel beds. Each sequence commences with fluvial gravels, followed by transgressive tidal succession. However, more than two inter-fingering oxidized beds were discovered from the tidal sediment cores, these making sequence analysis complicated. This study thus aims to re-interpret the depositional facies and architectural styles, and to reevaluate the sequence stratigraphic framework in the late Quaternary Baeksu tidal deposits. Geochemical and micropaleontological analyses with 40 OSL dates were implemented to redefine the sequences. Based on facies analysis, Baeksu tidal deposits are classified into five depositional units: 1) basal fluvial gravels, 2) mudflat/saltmarsh(MIS 5e), 3) gravelly spit/saltmarsh/mudflat(MIS 5a), 4) gravelly spit/mudflat(MIS 3), 5) tidal flat/intertidal shoreface/sandy beach deposits(Holocene). Among them, Unit 3 and 4 are reinterpreted to have formed indisputably in marine environments inferred from textural immaturity, vertical burrows, and marine dinoflagellates (e.g. Selenopemphix quanta, Selenopemphix nephroides). Consequently we redefined that two 5th-order sequences (subsequence) with 40 ka time intervals are nested within 4th-order sequences with 100 ka time intervals. Vertical and lateral variations of the inferred sequences and systems tracts reflect that local changes in sea-levels are the main controlling factors for the organization of multi-order transgressive tidal successions in this supply-limited setting. Interesting feature is the presence of cryptic bounding surfaces which can be only recognized by OSL dates and palynomorph assemblage changes, not by grain sizes and oxidized layers. Therefore, care must be taken to define the bounding sequences in lithostratigraphy-based studies.

The Messinian inter-evaporitic deposits of the Rio Aguas Section (Sorbas Basin, Spain)

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The Messinian stratigraphic section of Rio Aguas, renowned for its noteworthy gypsum supercones, was revisited with the objective of producing a refined petrological characterization, with special emphasis on the inter-evaporitic deposits. We created a 3D model of the Rio Aguas outcrop by means of UAV photogrammetry, allowed mapping three main lithostratigraphic units previously described: the Yesares Member, the Hueli Member and the Sorbas Member. The section was sampled for the detailed petrological, mineralogical and geochemical characterization of these units. Special attention was paid to the laminated marls that crop out between the selenite gypsum beds.

The results reveal a shallowing upward sequence with the following environments of deposition: (1) deep evaporitic (<200m deep), (2) intermediate deep with carbonates and gravitational instabilities and, finally, (3) a coastal environment. The evaporitic unit (Yesares Mb) consists of the alternation of selenitic gypsum beds, including megacones, and fine-grained laminated inter-evaporitic deposits. These laminated layers contain significant amounts of gypsum. The variations in gypsum crystals and textures observed in these layers allow distinguishing between syn-sedimentary, early and late diagenetic gypsum. Alternations of micrite with layers including fragments of gypsum crystals in association with micas indicate frequent detrital inputs of gypsum grains into the basin. Lenticular gypsum crystals that grow across lamination, displacing the sediment and poikilitically cementing mica grains, reveal their early diagenetic origin. Finally, gypsum veins that crosscut the laminae or develop parallel to discontinuities correspond to a late diagenetic origin.

The presence of detrital gypsum in the inter-evaporitic deposits reveals the erosion of previously deposited gypsum beds, suggesting that inter-evaporitic deposits are probably related to precessionally driven sea-level fall episodes associated with insolation minima and not maxima as previously proposed. This shallower situation could favor a complete circulation in the entire water column losing previous water stratification during the deposition of evaporitic beds.

Gravity flow deposition controlled by syndepositional faults in continental faulted basins

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Gravity flow deposition have been well studied in Marine environments, but the control of syndepositional faults on the sedimentary architecture of gravity flow deposition on a fine scale is still not well understood in continental faulted basin. Here we analyze the controlling effect of syndepositional fault on gravity flow deposition. Based on the comprehensive application of core, logging and three-dimensional seismic data, we analyze the morphological parameters statistics and grain size of the gravity flow channel of Shahejie Formation in Banqiao Oilfield, Bohai Bay Basin, and explore the sand body distribution and sedimentary characteristics of gravity flow deposition controlled by syndepositional faults in complex fault block areas of faulted basins. The results show that the activities of syndepositional faults cause obvious differences in lithology, grain size and sedimentary structure of gravity flow sandbodies in different fault blocks in the study area, which fundamentally controls the sedimentary mechanism and distribution of gravity flow sandbodies. Gravity flow channel is easy to pass through the less active part of the syndepositional fault and deflect or be restricted at the more active part of the syndepositional fault. In a single syndepositional fault footwall or graben area, it is easy to form the lateral overlapping pattern of multiple stages of gravity flow channels in the vertical direction. In the horst area controlled by syndepositional fault, it is easy to form an isolated channel pattern in the vertical direction. In addition, the increased activity of syndepositional faults provides sufficient accommodating space for gravity flow deposition. Finally, the boundary of a single channel sand body is determined, and the three-dimensional architecture model of gravity channel is summarized. In conclusion, the controlling effect of syndepositional faults on gravity-flow deposition can provide useful guidance for relevant studies in Bohai Bay Basin and other basins in the world.

The Case of the Shrinking Sabkha: the future of sabkha research in the UAE

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The geological significance of the southern shore of the, then, Trucial Coast was first recognised in the late 1950s. The next decade saw a flurry of activity, both in the sabkhas of the emirate of Abu Dhabi and within the adjacent shallow waters of the Arabian Gulf. These early expeditions faced considerable logistical challenges to undertaking research in this remote inhospitable environment. For this reason, much of the early research was undertaken close to the island of Abu Dhabi.

As 'oil money' allowed the UAE to develop its infrastructure, it became easier to travel further afield and a new generation of researchers visited the region, among them one Judith McKenzie. The sabkha leant itself to a vast range of topics including depositional architectures, recent dolomitisation, microbial mat communities, sabkha hydrogeology, sea level fluctuations, evaporite mineral development and hardgrounds.

The last 20 years have witnessed a resurgence of interest in the coastal sabkhas of the Middle East. Facies geometries, microbial communities and early cementation are all hot topics and dolomite is once again very much in the spotlight

Sadly, the very developments that opened the sabkha to researchers are rapidly destroying this irreplicable geological setting. Increasingly ambitious coastal developments such as dredging, road construction, new industrial complexes and sprawling urban developments have all taken their toll on the sabkhas of Abu Dhabi. Back in the 1960's, when the importance of this unique natural laboratory was recognised, ~150 km of pristine coastal sabkha existed along the Abu Dhabi coast. By 2013 this figure had dropped to 54 km. Today, less than 40 km remain.

At what point does the sabkha no longer become viable? Are we approaching the end of sabkha research in Abu Dhabi?

When it's gone, it's gone.

A revision of the depositional model for modern and ancient, tectonically-confined tidal straits

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The early depositional model unveiled for modern and ancient, tectonically-confined tidal straits was originally based on observations of present-day case studies combined with outcrop strait-fill successions in southern Italy. This model delineated four distinctive depositional zones, arranged laterally from the narrowest strait centre to its exits: (i) the strait-centre zone, correlated with tidal current maxima, characterized by a scarcity or absence of sediments; (ii) the dune-bedded zone, where deposits coalesce into dune complexes, owing to the expansion of tidal flows; (iii) the strait-end zone, marked by a deceleration of currents, resulting in the accumulation of thinly bedded, fine-grained sediments; and (iv) the strait-margin zone, where sediment mass-flows cascade down tectonically active, steep margins toward the strait axis.

This note presents a revision of this early model. While upholding the fundamental four-folded division into distinct zones or environments, the new model suggests supplementary processes and sedimentological features, including: (i) gravel furrows, ribbons and obstacle marks typical of modern strait-centre zones; (ii) tidal sand ridges characteristic of overfilled straits, alongside the presence of 'patchy' bedform fields, indicative of underfilled straits; (iii) bedform interference and the presence of sandy contourites in strait-end areas; (iv) deflected deltas, tidal flats, and tide-reworked beach ridges along the strait margins.

The depiction of tidal hydrodynamics now transcends its previous simplistic bidirectional representation, suggesting rotatory patterns in the strait exits, capable of exerting some influence on the strait-bottom.

The stratigraphic analysis of ancient strait-fill successions may reveal: (i) 'transgressive' vs. 'regressive' stacking patterns; (ii) distal strait-end successions, now incorporating contouritic deposits; (iii) non-tidal, fluvial, marginal-marine or open-shelf deposits as precursors or successors of strait sedimentation.

The combination of sediment-accumulation rate, accommodation space, and sea-level changes may result in predictable stratigraphic patterns for tidal straits, serving as proxy for interpreting similar subsurface strata.

Morphosedimentary behaviour over the last two centuries of hypertidal river mouths. A multi-proxy comparison study of estuaries in the English Channel (NW France)

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The 19th century is a switching period between the Little Ice Age and the global warming recent period. The later intensifies since the last 50 years, as a result of increasing human activities, with, among others, an acceleration of sea level rise and a higher frequency of extreme events (floods, storms). At the same time, coastal management has increased. This global change had major impacts on the morphosedimentary behaviour of estuarine systems in the general sediment-starved context of the English Channel. The aim of the present is to study and to compare morphosedimentary changes of estuaries over the last two centuries. The mouths of the Orne and Somme rivers are two hypertidal estuaries (spring tidal range: 8 to 12 m) located along the french coasts of the English Channel, in Normandy and Picardy respectively. Both are characterized by low water discharges, very low sediment supplies and are highly modified by human activities. Our objective is to determine whether these estuaries show comparable trajectories in relation to global warming and despite managements. The compilation of old maps and photographs allowed to retrace and compare the palaeo-morphologies of the studied estuaries using GIS tools. In parallel, high-resolution sedimentary analyses were performed on sediment cores (facies studies, grain size analysis, hyperspectral and XRF measurements). 14C, 210Pbex and 137Cs datings complete the datasets and enable the comparison of the evolution of the estuaries since the 19th century to be made. Among the results, geochemical differentiation between the two sites is highlighted. For each estuary, factor interactions control geochemical signatures and their variability. This will help in understanding how the different sedimentary sources contribute to the system evolution, through the determination of sediment origin, transport and mixing agents and their variability. The geological substrate is one of those factors.

Grain textures produced in natural sand fluidisation and their application to sand injection diagnostics

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During sand fluidisation and injection, numerous high velocity intergranular collisions occur, driven by the predominantly turbulent nature of high velocity flow. These collisions produce intragranular micro-fractures and intense fracturing of grain surfaces. Surface chipping and fragmentation of fractured grains lead to modification of grain shapes that decreases textural maturity and generates silt- and clay-sized framework grains. Distribution of micro-fractured grains is random, and no evidence of concentration along fractures or sedimentary structures is found.

Prevalence of micro-fractured framework grains and low textural maturity are diagnostic of sand fluidisation and injection. Other diagnostic micro-textures produced by sand injection include mudstone clasts with sand-propped micro-fractures and surfaces with embedded sand grains, a paucity of internal structures produced by grain traction and, preservation of features that record intense subvertical fluid movement.

Herein, micro-textural analysis is applied to support interpretation of core data and to differentiate sand injectite facies. Data from well N24/9-14ST2 in the Froskelår discovery (South Viking Graben), demonstrate how a depositional sandstone that directly overlies a sand extrudite is differentiated. Through application of micro-textural analysis, we can demonstrate that the depositional sandstone is genetically unrelated to underlying sand injectites.

Sedimentary records for a microcontinent release and assembly in Jurassic central Tibet

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Embedded among the ribbon continents of Tibet, several small microcontinents within the suture zones offer a unique window into pre-Cenozoic crustal growth and Tethyan dynamics. Despite their geological significance, these microcontinents have been understudied in plate tectonic reconstructions, leaving critical questions surrounding their formation, assembly along continental margins, and regional tectonic impacts unexplored. This study reports the discovery of Paleozoic shallow marine limestone and sandstone within the Bangong-Nujiang suture zone and interprets them as components of an independent microcontinent. Provenance analysis of the Upper Paleozoic deltaic sandstone, interbedded with glaciogenic sequences, reveals characteristics aligning with the Lhasa Block, indicating the attachment of the microcontinent to Lhasa during that period. The microcontinent rifted away before the deposition of radiolarian chert over the ophiolite during the Middle Triassic (Anisian). Subsequently, during the latest Middle to Late Jurassic, the microcontinent collided with Qiangtang, resulting in upper plate shortening, ophiolite obduction, and the development of foreland basins.

Lithification of Anthropogenic Geomaterials into Sedimentary Rocks

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As well as modifying natural sediment cycling, humans also create and deposit geomaterials on the Earth's surface. Large volumes of anthropogenic geomaterials are being dumped by humans on the Earth's surface. These can have a wide range of properties and origins and are typically unconsolidated sediment-like deposits, from very fine cement kiln dust to granule-pebble sized particles of furnace slag. Anthropogenic geomaterials are voluminous (e.g., an estimated 500-700 Mt of iron- and steel-making slag are produced globally each year [1]), while production is forecast to increase [2]. Additionally, there are unquantified billions of tonnes of legacy slag from former iron- and steel-making that are disposed of across the globe. As a result, there is significant potential for creating new rocks in the geosphere [3] which are anthropogenic (i.e., composed of anthropogenic geomaterials).

In this talk we will show how anthropogenic geomaterials deposited by humans can be lithified to form anthropogenic rocks, using case study sites where iron/steel slag and cement clinker deposits have become lithified. We present field and laboratory (X-Ray Diffraction, Scanning Electron Microscopy, and stable isotope data) from these case study sites to document the lithification of the anthropogenic geomaterials through mineralisation of atmospheric CO_2 as a cementing phase.

Improved understanding of the lithification of anthropogenic geomaterial deposits to form anthropogenic rocks has implications for ground stabilisation and atmospheric carbon dioxide removals. Furthermore, such anthropogenic rocks may become a significant part of the sedimentary rock record for the Anthropocene.

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Jurassic deserts and CO2 sequestration: the Glen Canyon Group in Utah, western USA

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The Early Jurassic in the Western Interior of USA consisted of an extensive desert environment, including one of the largest ergs in geologic history. The Navajo erg has been estimated to extend as much as 2.2 million square kilometers, though the preserved extent is somewhat smaller. The Mesozoic was a global greenhouse phase, and during the Jurassic this region experienced fluctuations in climate aridity, reflected in the depositional environment. In addition to extensive dunefields, interdune deposits (lakes and oases) and fluvial systems are also documented within formations of the Glen Canyon Group.

The Navajo Sandstone has received much attention as a potential CO2 injection target in recent years. It consists of thick, aeolian sandstones with high porosity and permeability, occurs in both outcrop and subcrop, and has industry data. Mapping of stratigraphic and sedimentologic changes within the Navajo Sandstone has been undertaken in localized areas, however piecing together these studies and developing regional models for CO2 potential has not received as much attention. There is significant industry data across Utah, and utilizing this data to pivot from a focus on hydrocarbon extraction to CO2 injection is an effective way to move forward with green energy, and to meet carbon neutral emission goals. Using legacy well data, we are developing a more comprehensive study of the Navajo Sandstone as a potential CO2 reservoir, in addition to identifying other zones of interest within the Glen Canyon Group, and improving understanding of stratigraphic complexity within one of the most significant aeolian systems in the world.

Influence of hydrological variability on point-bar sedimentation: Insights from the meandering Powder River (Montana, USA)

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Recent attention among scientists has been drawn to the impact of distinct flow patterns and their temporal fluctuations on sediment deposition and preservation in meandering rivers. Such interest stems from the ongoing debate surrounding the validity of classical, planform-based facies models, for which pitfalls (such as coexistence of numerous planform styles along discrete reaches and change in planform at different flow stages) have been recently identified. Developing new facies models for fluvial deposits requires a comprehensive framework examining the connections between channel-body architecture, hydrological variability, and channel planform geometry and evolution. Within this framework, our study focuses on the point-bar deposits along a reach of the meandering Powder River in southeastern Montana (USA). Our primary objective is to analyze the imprints left on alluvial sediment architecture by the two distinct degrees of hydrological variability experienced by this river over the past century, punctuated by an exceptional flood event that occurred in 1978. This analysis draws upon an extensive dataset obtained from cutbank exposures and trenches. Two 250-meter-long cutbank exposures, showing point-bar deposits accreted between 1930 and 1978, were studied to characterize point-bar deposits accreted before the 1978 flood event. Two trenches, 70 and 105 meters long, were dug in point-bar deposits accreted after the 1978 flood. Sedimentary features of point-bar deposits both in cutbanks and trenches differ significantly from classical facies models describing heterolithic epsilon cross-bedding for point-bar bodies. Preliminary results highlight diverse sedimentary features attributed to varying degrees of hydrological variability, with reactivation surfaces and super-critical flow structures being more common in post-1978 deposits. This disparity indicates a distinct signature of different hydrological regimes and further corroborates the need to depart from the traditional planform-based approach to studying fluvial sedimentary deposits.

Decoding the Ediacaran sedimentary sequences within the Arabian Plate: A case study focused on Saudi Arabia.

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Saudi Arabia boasts some of the well-exposed Ediacaran sequences, primarily situated in nearly a dozen small sedimentary basins associated with half-grabens formed during the Pre-Cambrian to lower Cambrian Najd Fault System of the Arabian Plate, collectively known as the Jibalah group. Although numerous studies have been conducted in the region, questions regarding the origin, deposition extent, and potential for global correlation of these Ediacaran carbonates remain unanswered.
Leveraging advancements in geochemical techniques, an initiative has been launched to investigate prime exposures of these carbonates in various Jibalah group basins in Saudi Arabia. These basins host mix clastic-carbonate deposits, often exceeding 300 meters in thickness, from different formations within the Jibalah group. These sediments are believed to have been deposited around the same time or shortly after the Shuram-Wanoka negative $\delta^{13}C$ Anomaly event (570-560 Ma). In-depth sedimentological and geochemical characterizations, including whole rock $\delta^{13}C$ and $\delta^{18}O$ isotopes, thin-sections, XRD, XRF, and depositional model, are underway to deepen our understanding of these formations. Exact age estimation of these rocks will be the crucial factor before coming to any conclusions.
Preliminary data from the basin, focusing on whole rock $\delta^{13}C$ and $\delta^{18}O$ isotopes, supplemented by thin-sections, XRD, XRF is being used to develop a depositional model of these sediments. The examination of extant of diagenetic alterations in both clastic and carbonate rocks is also underway. The results obtained so far not only align with previous data within the same basin but also correlate with data from other Saudi Arabian basins and from Oman. Such correlations, when extended to comparable data from diverse Ediacaran sediments globally, are suggestive of a potential worldwide connectivity of the Ediacaran seas which can be used to answer the questions related to the Avalon explosion and the origin of pre-Cambrian life forms during and after the Neoproterozoic oxygenation event.

Characterisation and genesis of hypogene void systems in Mississippian carbonates, Derbyshire Platform, UK

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Mississippian strata on the Derbyshire Platform, UK, have experienced a complex diagenetic evolution including calcite cementation, compaction, dolomitisation, Mississippi-Valley-Type mineralisation, and karstification. Although the epigene karst system has been described, there is also evidence for hypogene karstification, which is the focus of this study.
Hypogene karst forms from upward-flowing fluids, but the processes governing its formation are still not well understood. On the Derbyshire Platform, the occurrence, fill, morphology, size, location, and geological context of hypogene voids, including association with faults, stratal architecture, and diagenetic phases, have been documented. Three classes of voids (ranging from ~0.5 to 10s of metres in width and ~0.5 to 20-30 m in height) have been identified and classified as: Type 1 - partially to completely mineralised; Type 2 - sediment filled; and Type 3 - open, vertical, and sub-vertical. Of particular interest are the very coarsely crystalline calcite crystals that occur within Type 1 voids, and, in some cases, at the base of Type 2 voids.
Petrographic analysis of coarsely crystalline calcite crystals reveals homogenous crystals with dull luminescence and an absence of zonation/chemical variation within the crystals. This suggests constant fluid composition and redox during crystal growth. Isotopic analysis shows low $\delta^{18}O$, reflecting precipitation at high temperature or from isotopically-depleted groundwater. The majority of $\delta^{13}C$ data are positive, but some negative values infer different groundwater chemistry and/or an input of magmatic CO_2 during volcanic intrusion.
This geological and geochemical analysis provides constraints for numerical models that aim to understand the genesis and evolution of hypogene void systems. Preliminary modelling results indicate complex patterns of dissolution and precipitation that are influenced by cavity morphology. Integration of these results with the field characterisation will be used to discuss their genesis and implications for predicting the distribution of hypogene void system formation in other carbonate platforms.

Past seasonal insights in continents: let's crack the climate code using clumped-isotope techniques

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The projected future global temperature increase will affect continental areas differently depending on their geographic position. Reconstructing past seasonality changes (i.e., temperature and hydrological conditions) at regional scale is fundamental to forecast the environmental (e.g., vegetation and moisture availability) and social economical (e.g., food availability) impact. The carbonate clumped isotope (Δ47) technique reveals the temperatures at which calcium carbonate (CaCO3) precipitated, thus of the waterbody, and in combination with δ18O provides the δ18Ow that give insight on the hydrological conditions. Ostracods are small aquatic crustaceans (0.3 - 5 mm), with a very stable low Mg calcite shell, capable of recording climatic and environmental changes at high-resolution in sedimentary archives of modern and ancient lakes. The novel ostracod-Δ47 lacustrine thermometer is able to disentangles and quantifies the effects of global climate changes at regional scale and has several advantages that makes it an attractive tool for paleoclimatic reconstructions: (i) It is not affected by vital effect, thus, it is independent of ostracod species and geography. (ii) It is applicable throughout geological time (iii) by combining knowledge of ostracod shell precipitation time that is species-dependent, it is possible to reconstruct past seasonality. (iv) Temperature reconstructions for all environments where ostracods live are within reach. At Lake Trasimeno (Italy) record (last ca. 50000 years) the application of the ostracod-Δ47 thermometer identifies warmer/colder and humid/dryer conditions during Greenland Interstadial and Greenland Stadial/Heinrich events respectively. A reduced seasonality is recorded during the low Holocene. The establishment of this new lacustrine proxy opens the door to new high-resolution continental paleoclimate and paleoenvironmental reconstructions.

Late Quaternary lake-groundwater interactions in Laguna de Fuente de Piedra (southern Iberian Peninsula) recorded by stable isotopes of gypsum hydration water

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Laguna de Fuente de Piedra playa-lake (southern Spain) is an ephemeral hypersaline lake which sedimentary sequence covers the Late Quaternary. In this study, we examine the stable oxygen and hydrogen isotopes ($\delta^{18}O$ and $\delta^{2}H$) of hydration water of gypsum ($CaSO_4 \cdot 2H_2O$) in its sediments. We use this method to reconstruct the isotopic composition of the paleo-lake water, acting as a proxy for changes in the lake's hydrology through the past 30 ka. The lowest $\delta^{18}O$ and $\delta^{2}H$ values prevailed during the Last Glacial Maximum (LGM, ~20 ka). Subsequently, $\delta^{18}O$ and $\delta^{2}H$ values of water increased gradually during the deglaciation, from 20 to 12 ka. The Holocene was characterized by a further rise in the isotopic values from 11 to 6 ka, while gypsum precipitation ceased after ~5 ka. Contrary to expectations, the lake exhibited relatively lower $\delta^{18}O$ and $\delta^{2}H$ values during presumed dry periods (e.g., LGM, when increased evaporative conditions were expected) than under wetter climates (e.g., deglaciation and early to mid-Holocene). This unexpected pattern could be explained by long-term interactions between the underlying saline aquifer and the playa-lake. During the LGM, the lake was ephemeral and primarily fed by sporadic rainwater and surface runoff, with minimal connection to groundwater. At that time, the lake contained relatively low-salinity water, resulting in the precipitation of gypsum with lower isotopic values of hydration water than in subsequent periods. Conversely, during wetter climate stages, such as the deglaciation and the early to mid-Holocene, aquifer levels rose, leading to salinization of the lake water, and precipitation of a greater amount of gypsum with higher $\delta^{18}O$ and $\delta^{2}H$ values of hydration water. We conclude that the observed pattern in the isotopic composition of the paleo-lake can be explained by fluctuations in the groundwater level position, in response to the long-term glacial-interglacial hydroclimate variability in this region.

Formalization of carbon isotopic stages and their link with climate in the Early Cretaceous

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The Early Cretaceous is punctuated by a series of disturbances in the carbon cycle, accelerated hydrological cycle and upheaval in the marine ecosystems, including the carbonate producers (Föllmi, 2012). Several of these disturbances are marked by positive carbon isotope excursions, while others are simply marked by widespread black shale deposits without large-amplitude carbon isotopic excursions. Only large-amplitude (>1 ‰ PDB) carbon isotope excursions are interpreted for global correlations. However, a recent update of the geologic time scale in the Early Cretaceous shows that long orbital cycles (1.2-Ma obliquity and 2.4-Ma eccentricity) impacted the fluctuations of the δ13C of bulk and belemnite carbonates in the Early Cretaceous. I review here carbonate and organic carbon δ13C data widely distributed in the world and show that these isotopic stages can be found in both organic and carbon isotope data from various climatic belts and can be used as correlation tools. In general, increase in δ13C correspond to increasing humid conditions, at least in the tropical belt, and data on some of these intervals document increase in temperatures. Consequently, these fluctuations are the consequence of long-term changes in seasonality, impacting weathering of landmasses, fertilization and productivity of the upper marine waters.

Dedolomitization of mid-Cretaceous dolomite of the Adriatic Carbonate Platform in SW Slovenia: the origin of diagenetic fluids

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In the Kras area in southwestern Slovenia, the succession of dark grey bituminous dolostones of the Albian-Cenomanian Povir Formation is locally intersected by decametre-size orange carbonate rock bodies, typically distributed along fractures and bedding planes, forming three-dimensional networks. Elemental, XRD and petrographic analyses show calcite composition of these carbonate bodies and indicate their formation predominantly through dedolomitisation of the host dolomite. Preliminary C and O stable isotope analysis indicates a meteoric origin of the fluids causing calcitisation, but possible sources and pathways of diagenetic fluids are poorly understood. The presence of underlying collapse dolomite breccia levels suggests that dedolomitisation could be caused by an upward recharge of Ca sulphate-rich solutions formed by dissolution of evaporites originally present in the dolomite succession. Processes of dissolution of evaporite-bearing deposits and related dedolomitisation phenomena are commonly explained by the uplift of carbonate platform sequences to the meteoric diagenetic realm. Diagenetic transformation of dolomite units of the Povir Formation could be related to development of the recent regional karstic hydrological system and/or to palaeohydrology, e.g., formation of meteoric diagenetic zones associated with synorogenic (forebulge) uplift of the carbonate platform during the latest Cretaceous/early Palaeogene. However, other processes such as burial diagenetic transformation, including possible influence of fluids associated with hydrocarbon migration on the hydrochemical evolution of the system, need to be fully evaluated. Here we present a petrographic and geochemical characterization of the dedolomite bodies and host dolostone in order to establish a paragenetic sequence that will help understand the multi-phase diagenetic history. Geometry and stratigraphic relationships of dedolomite and dolomite breccia units in the Karst area are compared with outcrops in other parts of the Adriatic Carbonate Platform.

Study of an outcropping deltaic reservoir analogue: From digital outcrops to 3D reservoir model (Roda Sandstones, Graus-Tremp Basin)

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The Roda Sandstone (Lower Eocene) outcropping in the Graus-Tremp Basin (South Pyrenean Basin) represent an emblematic deltaic geological formation within the sedimentology community. The quality of their near-continuous outcrops along a downdip profile and to the 520 m of boreholes cored in their vicinity makes them a valuable analogue for studying fluvial-tidal deltaic reservoirs. Analyzing such complex systems through numerical models enhances our comprehension of sedimentary facies heterogeneities and geometries.

Previous studies have presented numerical models of outcrops from decametric to hectometric scale, with some attempts at 3D modeling and flow simulations in the 1990s. However, a precise and up-to-date 3D model is crucial for accurately locating and understanding processes within the system, such as tidal reworking in fluvial-dominated tidal-influenced deltas.

This study focuses on constructing a photogrammetric model of a portion of the Y sandbody covering approximately 4 km², with a resolution ranging from 3 mm to 3 cm. Interpretation using VRGS software facilitates the extraction of quantitative data (paleocurrent directions, thickness variations due to erosion, reworking, aggradation, or progradation), qualitative information (identification and marking of major stratigraphic surfaces, field data digitization, and facies mapping on outcrops), leading to a better understanding of the Y sandbody's architecture and facies distribution.

The results reveal that the Y sandbody comprises seven deltaic lobes with progradation directions varying from southwest to northwest. These lobes exhibit diverse sedimentary structures resulting from the interaction between fluvial and tidal currents, particularly in the central and distal parts of the delta front. These interpretations are incorporated into a 3D geomodel filled with facies properties using Petrel software, allowing simulations to predict fluid flows in this reservoir type.

Reconstructing climate during deposition of the Devonian Prairie Evaporite Formation potash giant of western Canada

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The Middle Devonian (Givetian) Prairie Evaporite Formation is an economically important Phanerozoic potash giant, having accumulated across a quarter million square kilometers in the epicontinental Elk Point Basin of western Canada. Prairie Evaporite mines produce approximately one-third of global potash. Despite its importance, questions persist about its deposition. This study focuses on the "insoluble" minerals that are found disseminated within the potash and in regionally extensive and correlatable decimeter-scale beds that increase in abundance upwards. The clay mineral assemblage within the insolubles varies systematically through the stratigraphy. The oldest members contain predominantly illite, illite-smectite, and chlorite-smectite, while the youngest also include an odinite-like phase. This is the first recognition of odinite, a 7Å Mg-Fe-rich clay mineral, in the Prairie Evaporite. Recent odinite forms through authigenic precipitation from terrigenous Fe-rich substrate in shallow, tropical marine settings. As it typically undergoes burial transformation to chlorite-odinite intermediates, this marks a rare example of Paleozoic odinite that has not been affected by choritization and is one of the oldest known occurrences in the geologic record. Its presence allows the reconstruction of a secular trend in basin chemistry and clay authigenesis during potash deposition, suggesting a shift in the regional climate from arid during the deposition of the oldest potash members to more humid conditions during the accumulation of the youngest. The wetter climate intensified weathering in the surrounding desert, causing intermittent interruptions in potash deposition and triggering odinite authigenesis. These changes manifest as temporal trends in insoluble composition and abundance. These environmental changes ultimately contributed to the cessation of potash deposition, providing new constraints on the accumulation of this distinctive deposit. When expanded to the overlying strata, this interpretation provides a new regional, and perhaps global, framework for tropical climate cyclicity coupled with eustatic sea-level fluctuations through the Middle Devonian.

Normal fault influence on the propagation, architecture and fill of basin-floor submarine channels: insights from the Taranaki Basin, Offshore New Zealand

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Faults that express seafloor relief may influence channels in several ways; however, most syn-rift studies have focused on basin margin faults. Hence, the influence of extensional structures within basins on channel propagation, resulting architecture and fill requires attention. Here, 3D seismic and well data from the Taranaki Basin, is interpreted to document the interaction of structures and sediment conduits.

Two families of normal fault networks were mapped and demonstrably active in the Miocene. These comprise 1) faults with large throws (up to 200 m) and lengths >3 km, striking N-S, and 2) minor faults, typically splays with smaller throws (<50 m) and lengths <3 km trending NE-SW. Two Mid-Miocene channel systems were mapped, with overall flow to the NW. Abrupt (often >90o) localized diversions of the channels occur when channels approach the faults. In rare cases the channels are seen to erode over the faults. However, other styles of channel interaction with faults were observed, being: deflection, 'chevron style' diversion, and capture and confinement along hangingwalls. The architecture and fill of the channels also varies in response to the faults. Channels are narrow, with erosional profiles and complicated heterolithic facies in regions of intense faulting. Channels develop lower aspect ratios, becoming more sinuous, leveed, and demonstrating more conventional channel-fills in areas of weaker faulting.

Interactions between submarine channels and intra-basinal normal faults documented here record more complicated styles than hitherto recognized. Faulting influenced channel propagation, geometry, architecture, fill, and evolution. Understanding the relationships between faults and channels has implications for sediment transport and reservoir architecture, applicable to both maximising energy resources and climate mitigation efforts.

Muddy coral bioherms from the Late Devonian of South Devon: The toleration limits of Carbonate buildups as evidenced by the Type Devonian.

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Modern scleractinian corals generally require a specific set of environmental conditions in order to thrive, namely clear, warm, and high energy waters. In contrast, Palaeozoic corals were often comfortable in calm waters, settled on muddy substrates. Yet there must have been some limit to the sedimentary environment that they could tolerate. To explore this, we examined the Devonian fossiliferous rocks of South Devon, UK. While there has been considerable research into sediment stressed Palaeozoic carbonate systems in recent years in regions such as the Devonian of Germany and France, the sedimentology of the Type Devonian in the UK has received little attention for several decades, with no geochemical results published until now.

Here we report the results of fieldwork, optical and electron microscopy, and elemental and stable isotope geochemistry for a succession of coral bearing limestone-mudstone interbeds at Saltern Cove, Paignton, UK. Provisional fieldwork indicates that many of these corals grew in situ in this muddy environment rather than being washed in from a shallower carbonate platform; in this context, the outcrop can be seen as a series of small bioherms, up to ~3 m across and 1.5 m high, separated by interbedded mudstones and limestone that drape around the bioherms. This muddy host-rock lithology (coupled with a lack of stromatoporoids) suggest a relatively deep water palaeoenvironment, associated with significant inputs of muddy, terrestrial siliciclastic sediment. In some biohermal horizons, most of the corals have been partially or fully replaced by diagenetic silica, whereas other corals remain calcitic. While the growth of any individual bioherm was able to outcompete mud deposition for some time, significant smothering of mud (20+ cm) appears to have been terminal. This suggests that Palaeozoic corals may have been quite resilient though not immune to terrestrial inputs.

Sedimentary clay minerals archive a shift in global chemical weathering intensity synchronous with the Palaeozoic evolution of land plants

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What role did Palaeozoic vegetation play in enhancing silicate mineral weathering intensity? By providing a physical record of weathering reactions, clay minerals have the potential to archive changes to the range of these that developed in response to the evolution of land plants. Traditionally, extracting this information has proved challenging, contributing towards contradictory hypotheses regarding the likely weathering impact of early vegetation. It has been suggested that the evolution of vegetation through the Palaeozoic was unlikely to have been accompanied by any net increase in clay mineral production, because any large and sustained increase would violate requirements for mass balance in box models of the geologic carbon cycle. This contradicts other suggestions based on modern analogue, where extant plants are known to accelerate clay mineral formation by producing organic acids and chelates. To provide empirical evidence to ascertain which hypothesis is most likely, we have tracked the properties of clay minerals across this key evolutionary transition (71 sample sites from 1400 Ma to 300 Ma; the largest dataset of its kind). Our methods differ from previous unsuccessful attempts because we have been able to separate clay assemblages in fine-grained mudrocks by mineral origin (neoformed vs mechanically weathered) utilizing novel microbeam technology, anchored to geochemical proxies for weathering intensity (δ^7Li). The results of this survey clearly indicate that plant evolution was accompanied by a shift both in clay mineral diversity and mudrock distribution. Pre-vegetation mudrocks are depauperate of neoformed clays, with clay components instead dominated by mechanically weathered material. In contrast, mudrocks deposited after plants had evolved contain an abundance of neoformed material, up to c. 10% in any sediment sample. This previously unrecognised archive of empirical petrological evidence demonstrates a revolutionary transition from a global weathering environment dominated by physical erosion to one where plant-induced chemical weathering created neoformed sediment.

The sedimentary revelations of rapidly receding glaciers in the Ötztal Alps

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The Rofental is a valley within the Ötztal Alps of Austria that has a rich history of glaciological research, specifically the Vernagtferner glacier. This glacier had characteristic surging behavior in the 18th and 19th centuries and, along with the neighboring Guslarferner, advanced into the main valley as late as 1845. During this time, an ice-dammed lake formed and even caused outburst floods, affecting localities downstream. Now, as widespread recession is occurring at glaciers in the European Alps, previously hidden landforms and structures are being revealed at higher altitudes and give insight into the dynamics and processes taking place at modern glacial margins. Here we present the results of sedimentological and geomorphological mapping based on fieldwork and drone imagery in the Rofental area. These highlight aspects of the glacial forefield and the contrast between what can be seen in 2023 and snapshots from the past 30 years. Striking features include a beautiful array of flutes at the Vernagtferner and debris cones with preserved cross-stratification at various glacier fronts. Questions arise regarding observable trends in these features and how the associated meltwater systems have been modified in the past decades. In a changing climate, understanding how these new conditions affect the deposition of sediments and the parameters that govern them will be useful in deciphering glacial dynamics and seeing how they differ from the previous sedimentary record.

From the Tethyan Ocean to the Paratethys Sea: changes in the marine sedimentation across the Eocene-Oligocene boundary interval

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At the end of the Eocene, a global transformation unfolded, ushering in a cooler climate with permanent ice-sheets in the northern hemisphere. Concurrently, the Tethyan Ocean, spanning across low-to-middle latitudes in the Northern Hemisphere, split into the Mediterranean and Paratethyan seas. The Oligocene thus represents a pivotal shift from a tropical to a modern, cooler world, evident in sedimentary records and biotic turnover, especially in marine planktonic organisms sensitive to water-surface changes.
This study investigates the depositional environment and biotic changes during this transition in the Eastern Carpathians and Transylvanian Basin (Central Paratethys) at the onset of the Paratethyan Realm, specifically spanning the Eocene-Oligocene boundary interval. The transition from Eocene turbidites to Lower Oligocene anoxic hemipelagites (comprising brownish marls, clays, and cherts) is accompanied by fluctuations in Total Organic Carbon (TOC) and CaCO3 values, as well as significant shifts in δ13C and δ18O isotopes. During this period, calcareous nannofossil assemblages, particularly sensitive to water-surface changes, experienced pronounced variations. Species associated with warm-surface waters and open marine settings temporarily disappeared, giving way to endemic taxa dominating the lowermost Oligocene assemblages. These changes reflect both global climate shifts and the influence of Paratethyan isolation from the world ocean. In the Upper Oligocene, a return to turbiditic sedimentation reminiscent of the Eocene occurs, interspersed with short pelagic depositional intervals, such as laminitic limestones containing cosmopolitan taxa. This pattern indicates palaeogeographic changes, including a partial reconnection of the Paratethyan Sea with the world ocean. Overall, our findings shed light on the intricate interplay between global climatic shifts and regional geological dynamics during this critical period in Earth's history.

Carbonate sediment production in the Lakshadweep Islands: Insights into the evolution of Isolated Platforms

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The evolution of isolated carbonate platforms depends on various factors, notably hydrodynamics, carbonate factories, sea level and global climatic controls. Discerning the variability in sediment dynamics and the governing controls is pertinent to ascertain the resilience of the islands in lieu of climate change. The Lakshadweep Archipelago, in the Western Indian Ocean, provides an excellent repository to gain insights into the spatial variability of sediment producers and the consequences of these variations on island growth.

The Lakshadweep Archipelago comprises 36 coral islands with an average elevation of 2m. Sedimentological and petrographic analysis on forty–three samples from transects across the Agatti lagoon has been used in grain size, textural classification and quantifying various sediment components.

The island exhibits wider lagoons on the western shores, with the reef flat closer to the island in the east. The saucer–shaped lagoon with a maximum depth of 4m at its center is grainstone-dominated (80%), 18% packstone and 2% wackestone. Its composition ranges from 2 – 0.5mm (40%) to 0.25mm – 0.125mm (22%). Coral fragments and molluscs are the major sediment producers. Coral fragments contribute 35% in the 2 - 0.5mm fraction, increasing to 40% for finer fractions. Molluscs are relatively consistent (32%) for all sizes; decreasing with increasing depths. Foraminifera, accounting for 20% of the coarse grains, is abundant towards the south and the deeper regions. Algae comprise only about 8% for all size fractions. The interplay of hydrodynamics and sediment components in redistributing the components is evident, with the hydrodynamics governed by the Southwest monsoon. As ocean acidification and warming increase, these signal potential coral mortality and changes in the species of the other producers, leading to decreased production rates. Thus, determining the various sediment components and their relative contribution in producing sediment can have significant implications for the island's resilience to climate change.

Testing the origins of the Mg-silicates formed in the intertidal sediments of Lake Clifton (Australia): environmental versus microbiological divers

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The formation of low-temperature Mg-rich silicates has gathered a substantial interest in the last decades since these minerals are excellent paleoclimatic recorders in fluvio-lacustrine environments, offer crucial information about the geochemical cycling of metals in sedimentary basins, or play relevant roles templating early diagenetic mineral phases. Mg-silicates form volumetrically significant deposits in lacustrine settings commonly associated with alkaline and/or saline conditions developed in hydrologically closed and evaporitic basins. The chemical evolution of these environments tends to feature a range of pH, alkalinities, salinities, PCO2, Mg/Si ratios, and cation chemistries favouring the formation of many Al-free, Mg-silicate minerals such as sepiolite, kerolite, stevensite or talc. Previous laboratory work has contributed to elucidate the chemical and biological constraints involved in Al-free, Mg-rich silicate neoformation; however, to understand the interaction of physico-chemical and biological mechanisms towards mineral formation in natural environments remains a paramount challenge.

In this work, facies, petrographic, hydro-chemical and microbial genomic data from the Lake Clifton coastal lagoon are integrated for the first time with geochemical and thermodynamic modelling to interrogate the system about the causative mechanisms underlying the formation of Mg-silicate aggregates and aragonite peloids as shoreline sediments. The fact that these incipient minerals coexist with the well-known intertidal thrombolite buildups offers the opportunity to quantify the environmental (pH, alkalinity, Mg/Si ratios, degree of water mixing or evaporation) and microbiological influences (EPS templating effects, or microbial metabolisms) underpinning early mineral formation, and also, to evaluate the preservation potential of these processes and signatures in lithified microbialites through a ~2,650 years-long diagenesis.

The Toarcian Oceanic Anoxic Event recorded in carbonate concretions from the Lower Jurassic of South Germany

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The Early Jurassic Toarcian Oceanic Anoxic Event (T-OAE) is a well-studied hyperthermal event of particular relevance for understanding today's climate change. It is associated with rapid global warming, ocean acidification, a rising sea level, and a severe biotic crisis affecting marine ecosystems. The environmental perturbations accompanying this event are recorded in numerous sections by a negative δ13C excursion, but also by changes in sedimentary processes, e.g., the deposition of black shales. This study presents a detailed microfacies analysis of an upper Pliensbachian/lower Toarcian succession from South Germany (Buttenheim clay pit, Bavaria) reconstructing the environmental conditions shortly before and during the T-OAE. The studied area represents a clay-rich facies located close to the western margin of the Bohemian Massif in the European epicontinental sea (EES). A peculiarity of the Buttenheim section is the abundant occurrence of early-diagenetic carbonate concretions which preserved (syn-)sedimentary features. Late Pliensbachian deposits contain a diverse benthic community colonising the soft sea floor and occasional hardgrounds formed by exhumed concretions as well as a diverse nektonic fauna. Intense bioturbation suggests that the redox boundary was located well below the sediment-water interface at that time. A drastic facies change occurred after the Pliensbachian/Toarcian boundary. Rocks of Toarcian age consist of finely-laminated marls which are devoid of benthic organisms and bioturbation traces, but are rich in planktonic organisms. The diversity of nektonic organisms is reduced. These observations argue for the absence of oxygen at the sea floor and in the deeper parts of the water column which means that the widespread anoxia during the T-OAE reached far into the south-eastern part of the EES.

Stratigraphic architecture of Triassic aeolian deposits in the context of low-latitude Gondwana: Sambaíba Formation, Parnaíba Basin, Brazil

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Aeolian deposits are important paleoclimatic proxies with dune sets being crucial in the reconstruction of past wind regimes. The high-resolution architectural analyses of aeolian deposits allow the interpretation of the genetic events, paleoclimatic conditions, and auto- and allogenic processes operating in these sedimentary systems. The Sambaíba Formation, Triassic of the Parnaíba Basin (N-NE Brazil), records an aeolian succession up to 400 m thick deposited in the context of central Gondwana, which is overlain by volcanic rocks of the Mosquito Formation (~200 Ma). Three genetic units delimited by supersurfaces were defined in the Sambaíba Formation. The lower unit exposes a series of smaller cross-trough stratified sets, bounded by slightly inclined upwind interdune surfaces, which are truncated by a subhorizontal extensive surface, representing an angular unconformity. The middle unit preserves at its base a series of small cross-stratified sets, bounded by subhorizontal interdune surfaces. These basal sets are overlapped by one exceptionally large (~70 m) cross-stratified set, recording the partial preservation of aeolian bedforms by the overlain lava flows. The upper unit comprises the interlayered aeolian deposits and lava flows. There is a complex variation of aeolian dunes morphology observed in these deposits alternating between simple, locally composite, crescentic, and complex linear aeolian dunes. These three genetic units were formed under different conditions or at different times, indicated by the nature of the surfaces between them. The mean paleocurrents to W-NW of these deposits suggest that trade winds prevailed during the Sambaíba accumulation. The dominance of aeolian dune deposits attests to the arid conditions in the low latitudes of central Gondwana during the Triassic. The genetic process, represented by internal surfaces, supersurfaces, and interaction between different depositional systems, led to the creation of significant heterogeneities. This study case can provide significant insights into sedimentary processes of accumulation and preservation in aeolian systems.

Characterization Analysis of carbonate reservoirs by different methods of hydraulic flow units, a case study of the Búzios and Mero fields, Santos Basin.

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Complexity is inherent in carbonate sequences, contributing to uncertainties in reservoir characterization and the correlation of facies and petrophysical properties at different scales. This study aims to investigate reservoir and non-reservoir intervals in the Búzios and Mero fields in the Santos Basin by employing hydraulic flow unit rock typing using three methods: FZI, R35, and S-curve FZI. Data from 26 wells were analyzed, including over 2200 thin section images from the Barra Velha Formation, drill core descriptions, and a comprehensive well log dataset. Integration of permeability and porosity measurements, obtained through routine well analysis and NMR well logs, using Schlumberger's Techlog software, revealed preliminary results, including the identification of potential reservoirs in the Barra Velha and Itapema Formations. Thin section images aided in characterizing pore types and understanding the role of diagenesis in porosity generation. This approach contributes to a better understanding of Pre-Salt carbonate reservoirs and can be applied to reduce risks and production costs in various oil fields. Furthermore, it serves as a predictive tool for reservoir behavior across different intervals.

Ferron Sandstone coal-bearing coastal plain deposits as a source of Rare Earth Elements and Critical Minerals

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The shoreface and deltaic sandbodies of the Ferron Sandstone have long been a focus of sedimentary research, especially with regards to understanding subsurface shallow marine hydrocarbon reservoirs. Recent work however, has examined Ferron coal-bearing coastal plain deposits to ascertain their potential as a resource for Rare Earth Elements (REEs) and Critical Minerals (CMs). The Last Chance Delta system of the Ferron Sandstone was chosen for this study due to the presence of six laterally extensive named coal intervals (A, C, G, I, J and M coals) that cap seven of the eight highly organized deltaic sandstone units.

Core and outcrop samples covering the entire Ferron stratigraphy have been geochemically evaluated via pXRF and ICP-MS elemental abundance methods to quantify their REE- and CM-enrichment; a sample is considered enriched when REE abundance is >200 ppm. All of the named coal intervals analyzed show REE-enrichment, locally reaching >4800 ppm. Enrichment is typically concentrated in claystones within or adjacent to the coal seams, with only two of the named coals recording enrichment within lower-grade coals (brown and dull). Enrichment is geographically widespread and not confined to a specific location or mine. These results suggest that REE-enrichment is lithologically controlled and appears to have been influenced by early diagenesis and fluid movement. These results also support the utilization of active mines, decommissioned mines and coal processing waste piles for the future of domestic REE extraction, offering economic and environmental solutions to pressing global demands.

Evolution of Permo-Triassic Fluvial Systems in the Central Iberian Basin, Spain

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The Castilian branch of the Iberian Ranges in northeastern Spain boasts remarkable Permo-Triassic exposures, featuring syn-rift sediments deposited in the Central Iberian Basin during the Early Permian breakup of Pangea. Fieldwork was conducted at eight localities spanning 80 kilometres where sedimentary logs, digital photographs, samples for chemostratigraphic analysis and LIDAR data were collected. The research aimed to establish connections between controls that shape large-scale continental depositional processes and the stratigraphic record of fluvial systems.

Five sedimentary lithologies were identified and categorised into twenty-eight lithofacies elements. These were condensed into six architectural elements representing four distinct depositional environments. Emphasis was given to the Buntsandstein sedimentary rocks, a series of lateral basal conglomerates and axial alluvial red sandstone and mudstone beds that were deposited in sub-basins with episodically changing rates of basin-floor subsidence. Calculations of net continental sediment accumulation rates ranged from 0.025 to 0.119 m/1000 years. Muschelkalk deposits record the onset of the Tethyan marine transgression, with a rate of 0.017 m/year for the first 1.5 Ma and 0.046 m/year thereafter. Sedimentary structures, grain-size data and sandbody shapes were quantified to illustrate the complexity of fluvial sediments and provide an alternative to qualitative and diagrammatical descriptions of outcrops. Seven depositional phases were defined by combining key sedimentological data facilitating the creation of seven diagrams that elucidate how eustatic sea-level changes, local tectonics and a marine transgression governed the behaviour of the fluvial system.

Beyond the immediate geological implications, this research holds significance for the UK's energy industry. While originally intended for hydrocarbon reservoir definition, such as those in the J-block in the Central North Sea, Permo-Triassic fluvial sediments in outcrop play a crucial role in their potential application in reservoir models for Carbon Capture Storage, contributing to the UK's pursuit of net-zero goal by 2050.

Possible causes and effects of the Steptoean Positive Carbon Isotope Event at the Miaolingian/Furongian (Cambrian) boundary, western Newfoundland

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Sea-level changes, bottom water anoxia or dysoxia, and thermal-stratification of paleo-oceans have been identified throughout the Furongian of the upper Cambrian and may play an important role in biodiversity decline and evolutionary stunting known as the Furongian Biodiversity Gap (FBG). The apparent FBG is currently debated in the literature due to possible sampling bias, fossil preservation, and limited data, however, the Furongian period remains a time of major paleogeographic changes. The Steptoean Positive Carbon Isotope Event (SPICE) is a positive carbon isotope excursion of up to +5‰ $\delta 13C$(PDB) that lasts between 2-4 Ma at the beginning of the Furongian epoch. The causes of the excursion are still unknown. Currently, the SPICE is thought to express paleo oceanic perturbations due to increased isotopically light carbon burial instigated by elevated sedimentation rates, seafloor oscillations, and/ or anoxic conditions. With the SPICE coinciding with the beginning of the Furongian, the SPICE may provide critical information on paleoenvironmental health and the apparent lack of biodiversity at the end of the Cambrian. The objectives of this study are to: 1) identify the SPICE at different positions in the basin by examining exposures of the ancient ocean shelf, and proximal and distal slope in western Newfoundland, 2) determine if the magnitude of the SPICE Event shifts along the basin transect, 3) investigate whether or not the FBG is expressed at and after the Miaolingian/Furongian boundary in Newfoundland, and if so, examine the possible causes of the biodiversity shift and whether they are linked to the SPICE. The results of stable isotope analysis reveal variable expressions of the SPICE excursion at different locations, up to +5.15 at the most distal position in the basin. On the shelf, microbial carbonates increase in their occurrence following the SPICE Event, which also coincides with a possible shift in sediment provenance.

Diagenesis and fractures influence reservoir quality: a case study from the Albian-Cenomanian Natih Formation (Natih E), Northern Oman.

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This study offers new petrographic and geochemical investigations of the Natih-E Formation exposed in the Adam Foothills and Al Jabal al Akhdar area. Four logged sections were detailed for diagenesis. Fifty samples were thin-sectioned and stained for the petrography study. Forty samples were used for the coring analysis to evaluate the porosity and permeability. Elemental analysis (Sr, Mn, Fe, and others) is obtained from different cements using Inductively Coupled Plasma (ICP) Spectroscopy. The scan line method is used for reporting fracture intensity by counting the number of fractures per unit length along a sample line perpendicular to each fracture set to reduce the measurement deviation.
The petrography study revealed that the Natih Formation, comprising skeletal peloidal wackestone, packstone, and grainstone, was deposited on a shallow water carbonate platform. Based on petrographic and geochemical analyses, different diagenesis types of low Sr, Mn, and high Fe cement were identified as follows:1-fracture-filled, partially filled, unfilled fractures; 2-pore-filled cement; 3-syntaxial overgrowth; 4- anhydrite cement. Micritization and micrite envelop indicate marine diagenesis. Some fractures are filled with late calcite cement, and others are unfilled. Elemental analysis of cement shows low Sr and low Mn, with high F. The results of the porosity and permeability indicate that the reservoir is considered tight. The average porosity was 4 %, and permeability was 0.034 mD. The Natih-E unit displays numerous sealed normal faults that initially trend ~NW–SE and ~E–W. At the microscale, the fracture population collected in Jebel Madmar can be subdivided into three intersected sets: NW-SE, N-S, and NE-SW, with an average dip of 80°.
Three sequential stages of diagenesis were identified: 1) syndepositional diagenesis including micritization; 2) intermediate to shallow burial diagenesis characterized by dissolution, syntaxial overgrowth, and physical compaction; and 3) late burial diagenesis with pore-filling blocky calcite cement, anhydrite cement, stylolitization, and fracturing.

Testing meteoric water flushing as a factor on diagenesis of deep-marine turbidite sandstones - a case study from the Tertiary sandstones of Frigg and Grane fields, northern North Sea

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Meteoric water flushing into deep-marine environments is a topic of debate since the actual transport mechanism remains elusive. To evaluate the potential impact of meteoric water on early diagenesis of deep-marine sandstones, two submarine fan sandstone reservoirs, the Eocene Frigg (Frigg oilfield) and the Palaeocene Heimdal (Grane field) that have the same source area, were compared and contrasted by usage of imaging (thin section, scanning electron microscope (SEM)), mineralogical (X-ray diffraction (XRD), and hydrogeochemical modelling (Phreeqc) methods. Petrographic studies reveal that both sandstone reservoirs are at the eodiagenesis stage (<70°C) at the present day. However, the Eocene Frigg sandstones are characterized by geological features suggestive of potential meteoric water diagenesis, such as dissolution and kaolinization of the silicate grains, whereas the Palaeocene Heimdal sandstones show negligible alteration. The δ13CV-PDB and δ18OV-PDB values of siderites in the Eocene Frigg sandstones range from +5.2‰ to +16.7‰, and from -8.2‰ to -6.6‰, respectively, also indicating siderite formation during methanogenesis in meteoric pore water. Results from generic hydrogeochemical modelling scenarios lend further support to the hypothesis of meteoric water flushing. Thus, we suggest that massive meteoric water might have been brought into the Frigg turbidite sands by basinward migration of the meteoric water. This occurs because the East Shetland Platform experienced two stages of relative sea-level fall (during and at the end of the Eocene, Priabonian), and flushing might have taken place via connected incised canyons. The location of the Frigg sands deposited immediately below the Shetland escarpment and the narrow palaeo-shelf area may have facilitated such meteoric water incursions. Our study suggests meteoric water intrusions as a possible diagenetic control of deep-marine sandstones, and, therefore, meteoric water diagenesis should be considered in the prediction of properties of deep-marine sandstone reservoirs.

Tides to Glaciers: exploring sea-level variations and sequence stratigraphy in the Dandot Formation, Salt Range, Pakistan

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The Dandot Formation, a constituent of the Lower Permian Gondwanan Nilawahan Group in the Salt Range, Pakistan, represents a predominantly tidally influenced depositional environment. This study focuses on the sedimentological analysis and facies associations of the Dandot Formation, shedding light on its depositional environment and lithofacies composition. The formation conformably overlies the glacial-fluvial Tobra Formation and exhibits a sharp boundary with the overlying Warchha Sandstone. Fieldwork was conducted along the eastern, central, and western sections of the Salt Range, allowing for comprehensive measurements of outcrop sections of the Dandot Formation. Sedimentary analysis revealed the presence of distinct lithofacies, including flaser-laminated sandstone, lenticular-laminated mudstone, heterolithic, and matrix-supported conglomerate.
Through detailed sedimentological and petrographic investigations, five lithofacies and two facies' associations were identified. These lithofacies collectively indicate an intertidal and tidoglacial depositional environment. These lithofacies variations, along with the sharp conformable contact with the overlying Warchha Sandstone, suggest the development of depositional sequences within the Dandot Formation. Sequence stratigraphy provides a framework for interpreting the stratigraphic record in relation to changes in sea level and sedimentary processes. Petrographic studies of the Dandot Formation provided insights into the composition of the rocks. The petrographic analysis revealed quartz as the dominant component, comprising approximately 60-75% of the rock composition, along with feldspar constituting 1-7% and lithic fragments. The results of this study significantly contribute to the understanding of the sedimentology and facies associations within the Dandot Formation. The identification of distinct lithofacies and their associations provides valuable information about the depositional processes and environmental conditions that prevailed during the formation's deposition. This knowledge can be utilized in resource exploration and hydrocarbon prospecting efforts, enabling a better understanding of potential hydrocarbon reservoirs within the formation.

Pseudospar

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Lithification of carbonate mud involves a complete reorganization of the original material and pore space. According to Folk's seminal paper (1965) the fine-grained matrix in limestones is arbitrarily classified according to its grain size, with grains between less than 1 and 4 µm called "micrite", from 5 to 30 µm "microspar", and crystals larger than 30 up to a few hundred µm called "pseudospar". In this talk only pseudospar that is formed by neomorphism of carbonate mud is considered, not the one that results from inversion of organic skeletons. Whereas micrite and microspar can easily be recognised both in thin section and SEM pseudospar is often difficult to distinguish from pore-filling spar because with increasing crystal size it becomes more and more translucent, and on the other hand true void-filling spar can exhibit grain sizes down to microspar size. According to Folk both microspar and eventually pseudospar are the result of progressive aggrading neomorphism of a former micrite, a process where smaller grains are cannibalized by larger ones. In the 90s of the last century it has been documented that most microspar crystals in fact represent small low-Mg calcite cements which precipitated in porous aragonite-dominated mud in very shallow burial conditions rather than being the result of aggrading neomorphism as supposed by Folk. Pseudospar, however, has received very little attention. In this paper results from thin sections and SEM samples from Ordovician pseudosparitic bryozoan limestones are presented. According to the data the grain sizes of the pseudospar crystals depend mostly on the primary interparticle porosity. Some pseudospar crystals cross the boundary between originally empty (i.e. water-filled) pore space and sediment indicating that at least in this example they represent cement crystals that precipitated very early in an extremely porous sediment, and are not the result of any sort of recrystallisation.

Isotopic trends of an Aptian forced regressive carbonate wedge from a platform margin setting: Climatic or depositional signals?

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This study explores the potential climatic or depositional significance of the carbon and oxygen isotope values measured in an Aptian platform carbonate succession from the western Maestrat basin (Spain). In the study section, carbonate production and accumulation were controlled by a major drop and a subsequent rise in relative sea-level during the Aptian. The relative sea-level fall was of around 60 meters and occurred in less than 1 Myr. Therefore, the age and magnitude of this relative sea-level drop match with a globally reported sea-level event, tentatively associated with glacio-eustasy during an early Aptian cooling event.

Our geochemical results show that the studied Aptian regressive deposits are characterized by marked negative C and O isotope excursions. These isotopic patterns diverge from those reported in other studies linking climate and relative-sea-level changes. In particular, the correlation between positive O isotope excursions and relative sea-level regressions is commonly attributed to sea-level drops caused by the formation of widespread continental ice sheets during climate cooling events. By contrast, the trend towards more negative (or less positive) isotope values in the studied regressive deposits is interpreted here as the influence of the depositional and early diagenetic processes occurring in the exposed carbonate platform during relative sea-level fall. Thus, the δ13C values were probably lowered by the influence of the soil zone and the oxidation of organic matter, whilst the δ18O values were lowered by the presence of meteoric fluids in subaerial conditions. Therefore, we conclude that the isotope results provided here do not reflect the climatic causal origin of the Aptian major relative sea-level drop recorded in the Maestrat basin but rather the relative sea-level fall itself.

This study is an example of how carbon and oxygen isotopes values of platform carbonates can help elucidate changes in relative sea-level.

Investigating Playa-Lake System Carbonate Formation

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Within dolomitization studies, lacustrine sediments stand out as a particularly distinctive area of investigation. There are numerous recorded occurrences of non-detrital dolomite within Quaternary lacustrine settings. A multi-proxy terrestrial Late Quaternary record in the Antequera region in south-eastern Spain is presented as a case study to determine the physicochemical processes in carbonate and evaporite forming lakes. The sedimentary archive studied originates from a saline, arid, isolated lake, Laguna Fuente de Piedra (LFP), within a topographically shallow, closed basin with seasonal standing water that contains post-orogenic Miocene rocks and lacustrine and fluvial quaternary deposits. The playa system is bound by mountain ranges comprised mainly of Jurassic formations, along with minor cretaceous deposits of limestones, and dolostones.

To understand and provide an insight on the formation of dolomite in these systems, a structural and mineralogical description with the use of scanning electron microscopy, X-ray diffraction, in addition to geochemical analyses. Our XRD results show a domination of calcite, Mg-calcite, aragonite, in the first 12 meters of the lacustrine sediment core, followed by high % of Fe-rich dolomite with depth, along with clays, quartz, sulphates throughout the core. Exopolymeric substances (EPS) as a potential nucleation site embedding ovoidal dolomite with nanocrystals, in addition to presence of microbial structures in SEM imaging gives a view on the formation of the microbially mediated lacustrine dolomites.

Understanding carbonate formation in this natural setting is fundamental, offering insights not just into modern environments but also into the geological record of both Earth and Mars.

When did the Indus River take on its modern drainage configuration?

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The Indus River-delta-fan system records a history of Himalayan evolution. Our work seeks to elucidate the palaeodrainage of the Indus River, in particular when it took on its modern drainage configuration with respect to conjoinment of the main Himalayan (Punjabi) tributary system with the trunk Indus River. We leverage the fact that the Punjabi tributary system has a significantly different provenance signature to the main trunk Indus, draining mainly the Indian, rather than Asian, plate. Therefore, after the time when the Punjabi tributary system joined the main trunk Indus, the proportion of Indian plate material in the repositories downstream of the confluence should have a higher proportion of Indian plate material compared to the upstream repository. We compared bulk Sr-Nd data and detrital zircon U-Pb data from the Cenozoic upstream peripheral foreland basin and downstream Indus delta and Indus Fan repositories. We determined that repositories below the confluence had a higher proportion of Indian plate material compared to repositories above the confluence, throughout Neogene times. We therefore conclude that the Indus River took on its current configuration with the Punjabi tributary system draining into the Indus trunk river in the Paleogene. Pinpointing exactly when in the Paleogene the tributary system joined the Indus should be determinable from a shift to more Indian plate input in the downstream repositories only. Whilst the upstream repository records no change in Indian plate input from Eocene to Neogene times, a shift to increased Indian plate material occurs at the Eocene-Oligocene boundary in the delta, but sometime between 50-40 Ma in the fan. Further work is therefore required to understand the discrepancy between the two downstream repositories but nevertheless we can conclude that the tributary system joined the trunk Indus at or before the start of the Oligocene.

Understanding reef systems and carbonate depositional patterns in an active rift basin

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Heterogeneous sedimentation patterns are inherent to rift basins. These basins are characterized by facies varying at very short spatial and temporal scales due to the interplay between tectonics, climatic, hydroclimate and volcanic activities. The existing facies models are only solving part of the overall puzzle because of the lack of continuous and well-exposed outcrops. However, a coherent facies model is paramount to understand the complex sedimentary architecture in rift basins. The Danakil Depression (northern Afar) presents an excellent field analog for studying carbonate deposition in rift basins at the transition between continental rifting and future oceanic rifting. The semi-enclosed Danakil basin formed by rifting of the Arabian and Nubian plates and was connected several times with the Red Sea during the Pleistocene. Pleistocene Red Sea transgressions resulted in the development of coralgal reef and rudstone-floatstone deposits along the margins of the basin.

Field mapping, sedimentary logging, and petrography resulted in new integrative facies models for the Danakil Basin and allowed the better understanding of (1) paleoenvironmental gradients within the Pleistocene Danakil Sea and (2) factors controlling carbonate sedimentation in an active rift system.

During MIS 11, oolitic grainstones were deposited associated with patch reefs. Fringing reefs colonized the margins during MIS 7, while small patch reefs and rudstone–floatstones developed again during MIS 5. Eustatic sea level combined with local tectonic uplift around the gateway of the basin mainly controlled the accommodation for reef growth through time. Lateral facies changes along the margins reflect paleoenvironmental heterogeneity within time-equivalent transgressive units. This was induced by the morphology of the margins influenced by rift tectonics. More mature rift zones characterized by gentle slope margins favoured the development of extensive fringing reefs and beach deposits. Steep slope gradients are characterized by smaller coral patch reefs. Locally, enhanced fluviatile input affected reef growth and morphology.

Pyroclastic density current deposits of phreatomagmatic monogenetic volcanoes of the Quaternary Hutaymah Volcanic Field in the Kingdom of Saudi Arabia as a unique assemblage of volcanic geodiversity

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PDC deposits are commonly linked with phreatomagmatic explosive eruptions of monogenetic volcanoes. Hutaymah Volcanic Field (HVF) that is in the northern edge of the Neoproterozoic Arabian Shield formed 1 million years ago. The unique geological feature of this volcanic field is its unusually high number of phreatomagmatic volcanoes. HVF hosts broad (~2.3-km) and deep (200 m) maar craters carved into the syn-eruptive landscape. Most of the maars cut into pre-eruptive basaltic lava flows or excavated granitoid rocks of resurgent silicic calderas. The differential erosion, ongoing crater floor subsidence and crater rim retreatment generated superb exposure combinations in the largest maar craters of the HVF. In these craters the Neoproterozoic caldera infilling deposits are exposed within the crater floors, engulfed with PDC deposits of over 50 m thickness in their proximal position. The PDC deposits often start with high particle concentrated varieties that are rich in cored bombs, accidental lithics, and mantle or lower crust-derived xenoliths (metavolcanics, welded tuffs). This componentry indicates strong excavation power and rather lateral high particle concentration PDCs to operate in the vent opening-stage. Large sections with (~ 30-m thick) dune bedded lithic-rich PDCs are the main deposit types in proximal to medial sectors. These sections exhibit dunes with steady wavelength (~2-3-m wavelength) and amplitude (~1-m) traceable in distinct horizons over hundreds of meters. The erosional retreat of crater wall positions exposes the longitudinal facies variations indicating a rapid (<300 m) diminishing of proximal high particle density types to thinly dune bedded varieties that can be traced about 3 km from their source. These sites offer a unique view of the internal structure of PDCs raising the question if they formed by progressive aggradation or single depositional event of energetic, but short-lived explosive power. In this regard these locations are globally significant geosites with high geoheritage values.

Sediment texture and geochemistry as predictors of sub-depositional environment in a modern estuary using machine learning

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Sedimentary cores from the Ravenglass Estuary, NW England, lack some of the sedimentary structures which can be seen in other estuarine sands due to their unconsolidated nature, making it difficult to meaningfully interpret depositional environments using standard sedimentological facies analysis. Here we explore how sediment texture, obtained from laser particle size analysis, and bulk geochemistry, obtained from portable X-ray fluorescence, can be used independently, or in combination, to automatically classify sub-depositional environment and estuarine zone in a modern estuary. We have adapted an established machine learning workflow to select the most informative geochemical elements to be included in a training set to automatically classify sub-depositional environment at the surface of the Ravenglass Estuary.
The most important elements for modelling represent major elements of the most abundant minerals in the estuary, and minor elements likely representing provenance signals of sulfide mineral deposits present in the hinterland. Models that are trained exclusively on textural data significantly outperform those that use geochemical data when classifying sub-depositional environment but are comparable when classifying estuarine zone. However, the combination of textural and geochemical data in training sets improves model performance in all but one class when compared to separate textural and geochemical models.
We have applied surface-calibrated combined textural and geochemical models to classify palaeo-sub-depositional environment in geotechnical cores obtained from the Ravenglass Estuary to interpret their environmental evolution and build scaled correlation panels. This study demonstrates value in utilising textural and geochemical data in conjunction with machine learning methods to help reveal the environmental evolution of marginal marine sands.

Beyond Nadir: sedimentary response to a marine hypervelocity impact event

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Marine-target craters are rare on Earth, representing around 10% of ~200 confirmed impact craters, despite the fact that >70% of the Earth's surface is covered by water. These appear to be underrepresented in the geological record because of tectonic recycling, and a lack of high-resolution geophysical data across most ocean basins. The consequences of such events are therefore poorly understood.

The Nadir Crater offshore Guinea, West Africa, is a ~9 km diameter impact crater situated below 900 m of water and 300 m of Cenozoic sediment. New 2D and 3D seismic data allow us to image the crater in exceptional detail, and to understand the shallow deformation and surface processes associated with such an event. The data allow reconstruction of the crater modification stage, including stratigraphic uplift and collapse of the annular moat. This is succeeded by a phase of inward flow of sediments towards the central crater, forming the concentric 'brim'. However, polygonal faulting below the contemporaneous seabed also provides evidence of dewatering of shallow (~500 m) sediments across a much larger area, because of seismic shaking following the impact. Concentric ridges at the top of this layer were likely formed by shear at the seabed by a train of passing tsunami waves of >800 m amplitude. Large scars and gullies document the resurge of water back into the crater. These also show that a thick seismic package filling the crater formed within minutes after impact, capped by a stratified layer that may represent subsequent suspension settling.

This data provides us with a unique insight into the marine cratering process for a mid-sized (400-500 m) asteroid or comet. We now aim to ground-truth these seismic observations by retrieving sedimentary cores through the crater, with a drilling proposal currently under evaluation by the International Ocean Drilling Programme (IODP3).

Sedimentary petrology of the tracked bed with the greatest number of exposed dinosaur tracks in the world

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The Carreras Pampa dinosaur tracksite within Torotoro National Park (TTNP), Bolivia, showcases over 15,000 tracks, predominantly of theropods with a minority of ornithopods. These tracks are situated on a single, nearly uninterrupted bedding plane within the middle member of the El Molino formation (Maastrichtian, Upper Cretaceous). The tracked surface also displays ripple bedforms, mudcracks, and invertebrate traces. This study investigates the influence of substrate composition on the preservation of these numerous traces. Permission from TTNP facilitated the analysis of 13 samples, categorized into two similar lithologic groups.

All lithologies are characterized by the dominance (40 to 90% of detrital components) of ~800µm ostracodal grains exhibiting an unusual form. Single ostracod carapaces constitute less than 1% of all observed grains. Articulated and one-sided valves are loosely nested and connected by columnar and microspar cements. Articulated/nested valves predominate, alongside some single valve/nested grains and hybrid/nested varieties. Most nested grains exhibit thin calcite coatings, and all cements exhibit well-preserved microfabrics. Individual ostracod grains, oblate in shape, show no preferential orientation relative to bedding.

Two variations of ostracod-rich lithologies were identified. The more prevalent type includes 5-10% bimodally sized quartz grains and 1-5% ooids. The second type contains thin to thick, diffuse laminae of very fine quartz or 1mm scale, ovoid patches of quartz. Ostracods and quartz grains in these lithologies exhibit point to long grain contacts and are predominantly cemented by bladed to equant spar, with trace amounts of bitumen. Meniscus cement habits are common between nested ostracod grains, and some samples exhibit local patches of calcite mud matrix. Textures suggest that the tracked substrate was stabilized through early cementation related to nested ostracods, local calcite matrix, mixed grain hardness, and early phreatic cements. Carbonate grains may have formed in local shoals and been reworked into sand flats.

Differential organic matter burial during the Toarcian Oceanic Anoxic Event in the Qiangtang Basin, eastern Tethys

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The Toarcian Oceanic Anoxic Event (T-OAE) is characterized by significant environmental perturbation and climatic instabilities due to a substantial release of greenhouse gases. Organic-rich sediments are widely distributed in this time, while organic-lean sediments are also deposited in some sedimentary basins. However, what controls the differential burial of organic matter remains uncertain. Here we present high-resolution organic and inorganic and isotope geochemistry, mineralogical, and sedimentological analyses from the shelf organic-lean sediments of the Qiangtang Basin to reconstruct paleoenvironmental conditions, and factors that govern differential organic matter burial during the T-OAE in the eastern Tethys. The carbon isotope profile of the studied section displays a long-term negative excursion characterizing the Jenkyns Event, which is recognized in geographically widespread sedimentary archives indicating its global nature. Elemental ratios of Al2O3/MgO, Th/K, and Ti/Na reveal intensified continental weathering at the Jenkyns Event onset. Increased values of fluvial detrital proxies (i.e., Si/Al and Ti/Al) and the occurrence of coarser-grained sediments (i.e., silty mudstones) within the studied section indicated enhanced terrigenous input at the Jenkyns Event onset, which was driven by accelerated continental weathering at this time. The productivity-related Ba/Al and Cu/Al ratios reflect a low water column bioproductivity during the deposition. The lower Toarcian interval in the shelf environment of the Qiangtang Basin is characterized by fully oxidizing conditions intermittent with minor phases of dysoxic setting, especially during the Jenkyns Event interval. Combined with the organic-rich sediments in the proximal and more restricted lagoonal area, redox conditions and marine bioproductivity were responsible for the differential organic carbon burial in the Qiangtang Basin.

Sedimentological Analysis of the Middle Jurassic Garn Formation, Maria and Lavrans fields (Halten Terrace, Norwegian Sea)

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Stratigraphic patterns, facies distribution and sedimentological characteristics provide evidence on the magnitude, variability, and spatial dispersion and preservation of sediments. The aim of this study is to identify the sedimentary processes and reconstruct the depositional scenarios during the sedimentation of the Middle Jurassic Garn Fm. Using high-resolution seismic profiles, well logs and sedimentological cores, the study focuses on Maria and Lavrans fields, whose observed sedimentological features are here considered representative to characterize the Garn Fm. Our observations indicate that the investigated deposits can be subdivided into six major sand-dominated lithofacies, exhibiting a variety of cross-strata and cross-strata sets, ranging in thickness from 0.1 to 1 m and from 2 to 6 m, respectively. These moderately-bioturbated sandy intervals pass laterally to highly-bioturbated heterolithic, sand/mud intervals, which often occur at the base and top of the Garn Fm. The recognized lithofacies are interpreted as the result of the migration of a series of sand bodies in a seaway setting bounded by marginal incipient NE-SW faults. Cross-stratified intervals record the development of superimposed subaqueous bedforms (dunes) migrating under the influence of marine currents mostly unidirectional. Occasionally, the top of these bedforms were reworked by shoaling waves, indicating a relative shallow-water condition. The down-current and lateral fine-grained deposits are interpreted to represent the toe and the lateral fringes of the subaqueous compound bedforms. The Maria and Lavrans fields thus represents two of the several bedform fields developed during the Middle Jurassic within a segment of the so-called Laurentian Seaway, which separated the Laurentian Shield to the NW from the Baltic Shield to the SE.

Palaeo-environmental controls on the rise and fall of the Ediacaran biota

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Observed shifts in taxonomic diversity between three biotic assemblages of the Ediacaran biota–the Avalon (~575–560 Ma), White Sea (~560–550 Ma), and Nama (~550-539 Ma)–strongly influence current understanding of early animal evolution, and are considered to evidence biological radiation and extinction events. However, the influence of local palaeo-environmental controls on Ediacaran taxonomic diversity is not adequately accounted for in existing datasets. Brief or highly generalised palaeo-environmental descriptions for key localities, limited study of non-fossiliferous units, and differences in interpretation of strata by various research teams complicate palaeo-environmental reconstructions and global site comparisons. Here, we apply consistent field-based sedimentological and stratigraphic methods to reconstruct the palaeo-environmental context of key sites representing each Ediacaran biotic assemblage (from Australia, Russia, Canada, and Namibia), considering both fossiliferous and non-fossiliferous intervals. Our approach permits direct comparison of similar palaeo-environments between assemblages, and recognition of potential palaeo-environmental controls on the observed distribution of Ediacaran macrobiota. Preliminary findings suggest broad overlap in palaeo-environments between key sites, with deltaic, shoreface, and offshore shelves represented in all studied basins. However, subtle but important differences between sites have the potential to influence interpretation of true organismal diversity and community structure. For example, a higher prevalence of transported biota in the Nama assemblage compared to the White Sea or Avalon, and far more extensive deltaic deposits in the Avalon (100s of meters thick) than in the White Sea or Nama (10s of meters thick) may account for variation in community composition, ecosystem maturity, and organism size. Comparisons of taxonomic diversity through time that rely on comparisons between biotic assemblages must account for facies-scale palaeo-environmental variability, to distinguish ecological or environmental controls from evolutionary patterns. Macrofossils are strongly facies and environment-dependant in all studied sections, which impacts interpretation of late Ediacaran extinction events.

Ancient Hot Spring Organic Matter Preservation and Thermal Alteration

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Carbonaceous organic matter from the early Devonian Rhynie Chert hot-spring deposit of northern Scotland was examined with Raman spectroscopy. This was done to investigate whether and how the structure of the carbonaceous matter was changed by the thermal influence of the ancient hot spring waters, with analyses done on both the organic matter within the interbedded mud, and within the chert layers. The hypothesis was that organic matter (including carotenoid biomarkers) associated with the cherts had been in direct contact with the thermal waters, whereas the mud organic matter had not. Temperatures experienced during burial diagenesis would have been the same for both the chert and mud rock organic matter. The analysed data show identifiable differences in temperature experienced by the carbonaceous organic matter throughout the mud rock, and ongoing work will reveal if there are differences in temperature between the mud rock and the chert. In addition, the identifiability of ancient carotenoid biomarkers was examined, with accurate deconvolution remaining a hurdle in accurately discerning any preserved molecular remnants. Results from Rhynie will be here compared with Raman spectroscopic data obtained from modern, actively precipitating travertine hot springs in Viterbo, Italy. This comparison shows that many of the challenges associated with carbonaceous matter found when interpreting ancient hot-spring data are also found in modern hot-springs, perhaps implying that they are inherent to hot-spring deposits. The contrasting study of modern and ancient hot spring environments may increase the understanding of how the Raman spectra of organic matter can change in the geological environment and has consequences for current and future planetary geology missions.

Pennsylvanian facies and sequence stratigraphic analysis in the Oslo Graben: distinguishing tectonic and eustatic forcing during initial rifting.

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The Pennsylvanian Asker Group of Norway, up to 90 m thick, comprises the basal sedimentary-fill of the Carboniferous -Permian Oslo Rift, a volcanically-active basin. Three stratigraphic units are recognized, from base to top, as the Kolsås, Tanum and Skaugum formations. Minor extensional tectonism occurred during deposition of the Asker Group. However, during the Late Paleozoic icehouse, high amplitude eustasy was another factor influencing base-level, and in this presentation, we present evidence to distinguish fault-controlled depositional systems influenced by tectonism and eustatic controls.

The Kolsås Formation comprises red beds deposited within alluvial plain environments developed during an interval of passive subsidence. In contrast the overlying Tanum Formation shows a transgressive-regressive pattern, commencing with terrestrial facies comprising the deposits of ephemeral streams and flood plains with thick calcretes, and passing upward into shoreface/delta front facies capped by ?Moscovian shallow marine limestone, before being partly eroded by braid plain deposits, marking renewed base-level fall.

The regional fluvial paleoflow direction in the Tanum Formation is towards the master faults. Drainage pattern, growth faulting and the widespread coarsening upward trend of the Kolsås and Tanum formations all suggest an upward increasing tectonic activity in a dip slope setting within the initial rift phase. A Kasimovian-Gzhelian (?Stephanian B/C) plant-fossil rich succession of wetland, lacustrine and bay mouth bar facies is sandwiched between braid plain facies of the Tanum Formation and an overlying volcanoclastic fanglomerate of the Skaugum Formation is indicative of a sudden sea level rise. The abrupt changes in facies and numerous hiatuses or lacunas seen in the Pennsylvanian Asker Group are probably linked to Pennsylvanian glacio-eustasy, and the enigmatic late Moscovian marine incursion in the Tanum Formation might be correlative with the amplified eustatic signal close to the Moscovian-Kasimovian boundary in the US midcontinental and Donets Basin coastal onlap datasets.

Compound Clinoforms – Their Recognition in the Rock Record

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Compound clinoforms are well recognized in bathymetry data of modern muddy deltas, where strong waves and tides redistribute river-sediment discharge away from the shoreline clinoform across the 10s to 150 km subaqueous platform before redepositing sediment along the shallow dipping 1-2°subaqueous clinoform. Despite understanding how both negatively and positively buoyant plumes are assisted by storm waves, tidal currents, and fluid mud to cross the subaqueous platform, there are relatively few studies highlighting the variations of these deposits in the rock record.
In this study we review and interpret lithological data from 4 ancient examples (paleo-Orinoco Morne L'Enfer/Manzanilla formations; paleo-Colorado Delta; and the WIS Bearpaw/Horseshoe Canyon and Dunvegan formations) to illustrate how facies trends can be useful in distinguishing the subaerial clinothem from the subaqueous clinothem in the rock record. Major defining characteristics include: 1) The progradation of the thinner, sandier subaerial delta across the top of the 10's of m thick, muddy, irregular coarsening upward (CU) subaqueous delta which can result in a bipartite architecture. Significantly, the subaerial clinothem CU is capped by subaerial facies or coastal-plain deposits; 2) The accumulation of thick littoral fluid mud deposits on the subaqueous platform. Fluid mud is largely absent on the lower subaqueous delta front since its cohesive strength exceeds the down slope shear stress as wave and tide energy dissipates at the subaqueous rollover; 3) The wave-dominated shoreline clinothem can develop a distinct discontinuity — RSME (regressive surface of marine erosion), of autogenic origin, between the subaqueous clinothem and the shoreline clinothem; 4) The recognition of energetic platform facies including scours infilled with wave-current enhanced gravity flows that transfer sand to the subaqueous platform. Identification of the compound clinoform delta in the rock record has fundamental implications for paleogeographic reconstructions, inferred shoreline positions and predictions of the volumetric deltaic sink.

Evolution process and factors influencing the tight carbonate caprock: Ordovician Yingshan Formation from the northern slope of the Tazhong uplift, Tarim Basin, China

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The tight limestone of the Yingshan Formation (Ordovician) is a local tight carbonate caprock in the Ordovician Tarim Basin. It vertically overlaps with the hydrocarbon reservoirs. The diagenesis and evolution processes affect the closure of this type of caprock, but it has been scarcely studied. This research utilized thin section study, cathodoluminescence (CL) examination, isotopic analysis (carbon, oxygen, and strontium isotopes), fluid inclusion, and the well-logging data to evaluate the evolution process and factors influencing the tight carbonate caprock of the Ordovician Yingshan Formation from the Tazhong uplift, Tarim Basin, China. These tight carbonate rocks are mainly composed of micrite and grainstone. The caprock thickness of the upper Ying 1 and the upper Ying 2 members of the Yingshan Formation are 15–44 m and 8–80 m, respectively, showing good continuity. However, the seal rocks in the other members of the Yingshan Formation are discontinuous. Low energy facies zone, vertical vadose zone, slow flow zone, and zone with weak tectonic destruction are the main areas of caprock distribution. Karstification in the epigenetic stage and cementation in the burial stage are the crucial factors affecting the evolution and distribution of carbonate seal rocks. Paleogeomorphology, phreatic surfaces, original sedimentary environment, and fault distribution influence the karstification, thus enhancing the macro heterogeneity of caprock. Cementation is controlled by buried fluids (formation water, hydrocarbons, hydrothermal fluid) and improves the micro sealing of the caprock. Multistage tectonic movements and changes in the fluid environment constantly change the sealing property of the caprock, and the reservoir and seal rock can transform each other in the process of evolution. These results suggest carbonate reservoirs evaluation can thus be enhanced by combining caprock evolution to analysis effectiveness. This research explains the mechanism of the spatial distribution of carbonate caprocks and provides the theoretical basis for carbonate reservoirs exploration.

A new sedimentary cycle: Interactions of Anthropogenic geomaterials and marine processes resulting in the rapid lithification of coastlines

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Recent works have shown how humans are now the main geomorphic agents on our planet, releasing and transporting vast quantities of natural material. Large quantities of natural material that has been excavated and transported by humans is deposited as waste on earth's surface. Waste material is also produced when manufacturing anthropogenic geomaterial (e.g., slag, cement kiln dust).

Derwent Howe (Cumbria, UK) was a site of steel making since around the start of the 20th century with production ceasing in the 1980's. Large amounts (26,729,599 m3; 56 million tonnes) of steel slag was deposited as waste material at the foreshore, forming 3 extensive (maximum ~30m in height, 3km wide) cliffs of lithified material.

In this study we document the interaction of marine processes with lithified anthropogenic geomaterials and document a secondary sedimentary cycle where lithified slag deposits are eroded, transported, reworked, and deposited by marine processes. We use sedimentary logging, facies analysis, clast analysis and SEM datasets to demonstrate the rapid (~decades) lithification of the reworked material, that has since transformed the coast at Derwent Howe from a 'soft' coastline to a coastline that has a rocky foreshore and cliff face.

We discuss the impact of the secondary reworking and subsequent deposition and rapid lithification of anthropogenic sedimentary waste material and place our findings into a global context. The documentation of this processes opens many questions relating to the potential challenges (e.g., implications for biodiversity and modification of marine processes to hard rock coastlines) and opportunities, including CCS potential of reworked steel slag sites and engineering of coastlines for protection against rising sea levels and increased coastal erosion.

Tectonically-driven Carbonate Burial Diagenesis in an Orogenic Belt: the Middle Permian From Western Sichuan Basin (China)

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Carbonates have been accepted as sensitive achieves for brittle defformation history in the upper crust. In particular, recent advances in carbonate geochronology (LA-ICP-MS U-Pb dating) and clumped isotope thermometry (△47) provide potential for better understanding carbonate diagenesis and its relationship with regional deformation history in an absolute time-temperature framework. We applied the emerging△47/(U-Pb) thermochronometer and routine petrogeochemical tools to the middle Permian carbonates from Longmenshan orogenic belt that constitute the dominant reservoirs for several ultra-deep gas fields in western Sichuan Basin (SW China), aiming to reveal the possible link between diagenetic evolution and the basin-scale tectono-fluid events. Overall, the middle Permian carbonates show delicate diagenetic fabrics of structural imprints, such as fracturing and brecciation, zebra dolomites, and hydrothermal dissolution and cementation. Notably, U-Pb and Δ47 measurements suggest that diagenetic alteration of these carbonates correlated well with the two major deformation events of Longmenshan belt: one is recorded by the replacement dolomites and vug- and fracture-filling cements that yield U-Pb ages of 240 ± 12 Ma to 213.4 ± 3.3 Ma, probably corresponding to hot (Δ47 temperatures 88~104 ^{o}C) brine circulation driven by the thrust-related compression of Longmenshan belt during the Mid- to Late-Triassic time ; the other is achieved in the fault-cementing saddle dolomites and calcites with U-Pb dates (16.40 ± 0.74 Ma to 12.3 ± 1.2 Ma) of Miocene ages, representing a hydrothermal fluid flow event (Δ47 temperatures over 160 ^{o}C) during the Cenozoic reactivation of thrusting. Moreover, there seemed to be long-term cessation of diagenesis in these carbonates during most of the Mesozoic Era and Paleogene, which was consistent with the tectono-thermal quiescence of Longmenshan belt during this time. This study illustrates burial alone in tectonically-active sedimentary basins is not a sufficient driver for diagenetic alteration and highlights the geodynamic controls on fluid flow and consequent diagenetic evolution of carbonates.

The zircon story of the Niger River: natural or artificial disconnected sediment-routing system?

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The Niger River drains a large part of the West African Craton, offering an excellent example to evaluate the effect of natural and artificial barriers that may disconnect a sediment-routing system. The identification of river sediment source rocks, ranging in age from Paleoarchean to Jurassic is successfully accomplished by U-Pb zircon dating. This method is complemented by bulk-sand geochemical analysis (Zr, Hf, REE) and Nd-Hf isotope analysis, which allows for the precise determination and quantification of sediment provenance budgets. The exclusively Archean-Paleoproterozoic zircon signal in Guinea abruptly changes to mainly Neoproterozoic downstream of the Inner Delta. Similarly, the isotopic signature of sand shifts from highly radiogenic to less negative. In the Niger Delta, however, small populations of Archean zircons reappear, and both εNd and εHf values become more negative, indicating reworking of sand deposited along the coastal plain at earlier times, during an uninterrupted process of river sediment transport. The disconnected signal transmission can be attributed both to artificial factors (e.g. the larger dams that may have sequestered a significant part of Upper Niger sand), and to natural climatic changes. Discontinuous water discharge, influenced by seasonal flooding and a general decrease in the last decades, contributes to this phenomenon. This indicates that temporary or permanent barriers can profoundly impact sediment budgets and sediment composition, hindering a substantial portion of detritus from reaching the ocean, a further factor that must be given due consideration for river natural resource management.

Unravelling the key role of coastal processes and submarine canyons on shelf-to-basin sediment transfer mechanisms in the Southern Taranaki Basin (New Zealand): Insights from quantitative 3D seismic stratigraphy

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Along shelf margins, the evaluation of the lateral and vertical variability of deep-water systems, and the controls on their architectural organization, is critical to better predict where reservoir-quality sands could be present in various tectonic and climatic settings. From the Neogene onwards, a shelf margin developed in the Southern Taranaki Basin (New Zealand) under changing tectonic and climatic conditions, which constitutes a unique case study to better understand shelf-to-basin sediment transfer mechanisms.

Two high-resolution 3D seismic volumes were examined using the quantitative 3D seismic stratigraphy (QSS) workflow and seismic geomorphology. QSS aims at investigating the quantitative relationships between hydrodynamic regime along paleoshorelines, shelf-margin architecture and coeval deep-water systems. This approach is underpinned by state-of-the-art, full-volume 3D seismic interpretation methods that enable high-resolution seismic stratigraphic analysis (4th-5th order).

Strong progradational stacking patterns are predominant and indicate a dramatic increase in sediment supply due to the uplift of Zealandia during the Late Miocene to Pliocene and icehouse climatic conditions during the Pleistocene. Three and four types of paleoshorelines and deep-water systems are identified, respectively. Long run-out turbidite systems are the most common and present a classic tripartite architecture with: (1) gullies / canyons; (2) channels / levees; and (3) terminal lobes. Other remarkable features include sediment wave fields.

Results show no apparent correlation between shelf-edge trajectory angle and sediment partitioning, indicating that relative sea level was not the main controlling factor on sediment bypass. Linkages between fluvially-influenced coasts and long run-out turbidite systems strongly suggest that coastal processes were the major control on the initiation of turbidity currents, while the development of submarine canyons likely promoted the efficient bypass of sediments and the architectural maturity of deep-water systems. This study demonstrates the significant role of coastal processes and submarine canyons on the location, scale and timing of deep-water sand delivery.

Understanding the sole — from dinosaur leather to longitudinal ridges and furrows — mechanisms and implications

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Sole marks have until recently been used exclusively as palaeocurrent and way-up indicators, in marked contrast to aggradational bedforms such as ripples, dunes, antidunes, etc. all of which provide us with key flow information. Peakall et al. (2020), however, challenged this paradigm, interpreting scour marks (e.g., flutes) and tool marks (e.g., grooves and chevrons) in terms of flow types. Here we provide a radical synthesis and an entirely new mechanistic model for a range of sole marks that includes longitudinal ridges and furrows, and the so called 'dinosaur leather' structures associated with mud ripples. We interpret these as a third class of sole marks, alongside the existing classes of scour marks and tool marks. The work challenges very long held ideas; for instance longitudinal ridges and furrows have been considered to be scour marks since the early 1960s, an interpretation that we overturn here. Previously, sedimentary structures have been associated with either flow-induced drag (e.g., sand ripples; mud ripples), or post-depositional buoyancy-induced diapirism (e.g., load casts). Here, we argue that in soft muddy substrates, the two processes can combine during flows, with interaction between flow-induced drag and buoyancy-induced diapirism. Given that these processes occur at the flow-substrate interface, we term these structures 'flow-induced interfacial deformation structures (FIDS). We show that these FIDS provide evidence for the nature of the flow, in particular, indicating processes such as debritic heads, and flow transformation from lower to higher-concentration flows. They also provide information on substrate rheology. Furthermore, some of these structures have been all but forgotten in the literature with unidirectional flow indicators such as scales unused for palaeocurrent analysis for many decades.

Organic matter influence on ooid formation: New insights into classic examples (Great Salt Lake, USA; Triassic Germanic Basin, Germany)

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Ooids are coated grains composed of a tangential or radial cortex growing around a nucleus. They are common in carbonate deposits of almost any geological age and provide insights into environmental conditions. However, abiotic or biotic factors influencing their formation remain unclear. This study aims to advance our understanding of ooid formation with a multi-analytical approach (e.g., FE-SEM, Raman spectroscopy, µ-XRF) to classic examples from Great Salt Lake, USA and the Lower Triassic Germanic Buntsandstein Basin, Germany. Both deposits represent hypersaline shallow-water environments where ooids are closely associated with microbial mats. Great Salt Lake ooids are dominantly 0.2–1 mm in size, ellipsoidal to subspherical in shape, composed of aragonite, and contain organic matter (OM). Germanic Buntsandstein Basin ooids are mainly ≤4 mm in size, spherical to subspherical in shape, composed of calcite, and currently contain little OM. Despite the differences, both ooids have the same cortex structures, likely reflecting similar formation processes. Some Great Salt Lake ooids formed around detrital grains while others exhibit micritic particles in their nuclei. In Germanic Basin ooids, detrital nuclei are rare, despite the abundance of siliciclastic particles of various sizes in the host rocks. Germanic Basin deposits also include "compound ooids", i.e., adjacent ooids that coalesced with each other during growth, suggesting static in-situ development, which is supported by the lack of detrital grains as nuclei. Germanic Basin ooids also grew into laminated microbial crusts with identical microstructures, further indicating a static formation. Such microbial crusts typically form through mineral precipitation associated with OM (e.g., extracellular polymeric substances, EPS), suggesting a similar formation pathway for ooids. The inferred key-role of OM is further supported by features in radial ooids from the Great Salt Lake, which commonly exhibit, from their nuclei towards their surface, increasing OM contents and decreasing calcification.

Unraveling episodic dolomite cementation in Early Miocene rift lakes of the Eger Graben: Implications for MCO climate variability

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The lacustrine records from the Eger Graben in NW Czechia provide insights into the Miocene Climatic Optimum (MCO, 16.9-14.7 Ma)—a period now garnering attention due to its parallels with projected, near-future climate scenarios. We deciphered metal respiration, biogeochemical cycles, and microbial dynamics in the Eger Graben by analyzing the stratigraphic abundances of ferroan dolomite and siderite, along with bulk rock stable isotopes (C, O, N) and elemental concentration data from carbonate-rich strata. Potential pCO_2 fluctuations during the onset of the MCO are seen as likely controls of carbonate precipitation in the Eger's brackish alkaline paleolakes. Isotopic data reveal $\delta^{15}N$ values indicative of persistent paleoecosystem N_2 losses, and $\delta^{13}C$ values capturing a mix of dissolved inorganic carbon sources, including significant methanogenesis. Rising pCO_2 levels, exacerbated by a warm and humid MCO climate, accelerated silicate weathering in the hinterlands. Increased runoff enriched the paleolakes with magnesium, iron, sodium, potassium, and barium sourced from alkaline igneous rocks. Oxidized soil-derived nutrients were also introduced, promoting ferric iron-based heterotrophy and redox buffering, favouring anammox. The dolomitic (ankeritic) marl sediments exhibited europium anomalies, which other researchers might readily interpret as indicative of hydrothermal influence. However, the Δ_{47} paleothermometer shows that locking temperatures of early formed siderite in a basal concretion were ≤20°C, while the structure was never exposed to burial T>50°C. Dolomite abundances correlate with high concentrations of nutrient-like elements, further elucidating climate rhythms over the lacustrine microbial carbonate factory. K, Ba, and heavy rare earths were introduced during stages of enhanced chemical weathering, a phase of nutrient-perturbed redox stratified lake waters followed, seemingly linked to ferroan dolomite authigenesis. Notably, the presence of euhedral microcrystals preserved within clay floccules indicates recurrent episodes of resuspension of primary dolomite. Our findings propose lacustrine dolomite formation as a feedback mechanism potentially modulating episodically high MCO pCO_2 levels.

Understanding the Evolving Risks of Post-Wildfire Debris Flows in the Southern Wasatch Mountains, Utah, USA

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Debris flows are dangerous natural phenomena whose occurrence is more common in wildfire-affected landscapes. As the wildland-urban interface continues to expand and as climate change affects both wildfires and extreme precipitation events, the risks posed by post-wildfire debris flows will evolve as well. Here, we present the results of an investigation of a prominent debris flow fan in the Southern Wasatch Mountains of Central Utah, USA. The fan records a long history of debris flows with pervasive charcoal, suggesting a strong historical influence from wildfires on the initiation of past debris flows. In September of 2020, the area burned during the 6000 acre William Fire, and we began our initial site survey in Spring 2021. Following an intense rainstorm on July 30 2021, we returned to the site to find a new debris flow. We acquired UAV aerial images of the fan both prior to and after the July 30 debris flow. We generated digital terrain models (DTMs) from the aerial images and analyzed the DTMs to highlight patterns of erosion and deposition for the July 30th debris flow. We determined rainfall intensity-duration threshold for the initiation of the debris flow from nearby weather stations, and we examine both historical records and future predictions for rainfall patterns to investigate how often this threshold has been exceeded in the past and is expected to be exceeded in the future. We use this analysis as a starting point to understanding how the risk of post-wildfire debris flows will evolve in the future. By 2050, the population of nearby communities is expected to increase 300%. As these growing communities continue to sprawl further into the foothills where debris flows are common, we must be able to provide a more complete understanding of future debris flow hazards in light of a changing climate.

Mid Jurassic Estuary revealed by Spectral Decomposition on the Sele High (Norwegian North Sea)

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Subsurface architecture and geomorphology using high-resolution frequency blend imaging techniques reveals the depositional forms of a Middle Jurassic estuary, including buried channels, mudflats, and erosional surfaces. Understanding subsurface architecture helps reconstruct the evolutionary history of a Callovian coastal plain of the Bryne and Sandnes Formations of the Vestland Gp., which rests unconformably on Triassic clastic across the Mid Jurassic Unconformity on the Sele High.

This presentation aims to explore seismic geomorphology,(a) visualize depositional elements interpretation of plan-view seismic images,(b) demonstrate workflows for lithology prediction through seismic stratigraphy and (c) seismic geomorphology integration, and discuss the development of advanced analytical techniques to de-risk reservoir presence, highlighting its potential impact on geoscience compared to experimental analogue modelling and fieldwork.

The Sele High is a fault bounded structural high that was elevated relative to its flanks from early Permian to Late Jurassic times; Seismic geomorphology imaging of those sequences reflects this elevation through the evolution of facies through those times. Middle Jurassic reservoirs (Vestland Gp, Sandnes & Bryne Fms) were targeted and demonstrated to be present and effective in Dovregubben well (17/8-1).

Seismic images of Bryne Fm facies, dominated by inter-fluvial and coals, can be calibrated using core data. Sandnes Fm reflects drowning towards coastal plain environments, including tidal channels and bars depositing heterogeneous facies with varying reservoir quality. Seismic images of the Callovian drainage system on the Sele High reveal linear accommodation space above collapsed salt walls and an extensive distributary tidal estuary feature in areas where the Mid Jurassic Unconformity intersects with Triassic clastic substrate.

The dimensions of this Callovian estuary are around 13 km long (on the high alone - it continues off the High into the Ling Graben) and it widens from a few hundred meters width in its feeder distributaries to over 1500m wide as they coalesce.

Timing of salt deformation in the northern Delaware Basin, southeastern New Mexico, USA

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Late Permian bedded evaporite formations (Castile, Salado, and Rustler, in ascending order) in the northern Delaware Basin have been deformed without involving underlying formations. The features include a complicated salt ridge against the northeast margin of the Delaware Basin formed by Guadalupian-age reef deposits. Some areas upslope of the salt ridge show reduced salt thickness from migration downslope to the ridge. Local deformed areas away from the margin also show evidence of downslope salt movement. Local limited piercement has been suggested, but the evidence is inconclusive at this time. Along the eastern margin of the Delaware Basin, two separate Castile halite beds (HI, HII) have thickened up to double the thickness in nearby undeformed areas. Thicknesses of upper Salado and of the total Rustler display modest variations. More detailed analysis of specific intervals of these two formations continue, as there is local evidence of thinning due to syndepositional deformation. The Permotriassic(?) Dewey Lake Formation (aka Quartermaster Formation) overlies the Rustler and is both elevated and thinned significantly over segments of the salt ridge. We interpret this thinning as an indication of deformation of Dewey Lake prior to Triassic Santa Rosa Formation deposition. Furthermore, the Santa Rosa is thinned in the same area and entirely removed locally to indicate deformation prior to deposition of the overlying Triassic Dockum (aka Chinle) Group.

The evaporite formations thicken and display facies changes from west to east in the northern Delaware Basin toward the deformed area. These features indicate subsidence during late Permian and a modest slope consistent with downslope (eastward) migration of salt beds in the lower evaporite section and creation of the complicated salt ridge starting relatively soon after deposition of the lower evaporite beds.

Basement nature and basin physiography controlling sedimentary and petrologic variability of coarse-grained shallow-marine transgressive sandstones: a case study from the middle Eocene of the Ebro Basin (NE Spain)

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Coarse-grained shallow-marine transgressive successions deposited around basement topography can form good reservoirs. However, they are sometimes condensed and challenging to interpret in the subsurface, hence outcrop studies are key to understand them better. The Folgueroles Sandstone Fm. is part of a middle Eocene alluvial to shallow-marine succession of the Ebro basin, which overlies a deeply weathered basement high. It has been interpreted as transgressive, but a more detailed sedimentological and petrographic analysis is needed for its adequate characterization.
Several sedimentary logs were measured, sampled, and correlated across a 10 km along-margin profile. The unit is 6-80 m thick, and its composition is granitic with minor metamorphic and sedimentary components. It shows a sharp, basal surface, and includes 3 packages: 1) fine/medium-grained sandstones, with small-scale cross bedding, abundant glauconite and reworked bioclasts; 2) medium/very coarse-grained sandstones, with large-scale planar, tangential and trough cross-bedding showing dominant northward paleocurrents; 3) fine-grained bioturbated sandstones. The basal erosive surface and lower package formed during a relative sea-level fall; subsequent sea-level rise led to the intermediate and upper packages, deposited along a high-energy coastline, with alongshore reworking of coarse-grained alluvial deposits forming an extensive sandwave complex.
The studied succession onlaps the granitic/metamorphic basement to the SE, and a karstified Triassic paleorelief to the SW, where deposits of the Folgueroles Sandstone Fm. are absent. This suggests their accummulation was controlled by the basement configuration as they are only found where the weathered granitic basement was exposed and delivered sediment to the alluvial fans. The strong alongshore reworking was possibly enhanced by a narrow shelf configuration, constricted by the Pyrenean frontal thrust in the north, and the basement highs in the south. Results of this work therefore highlight the importance of basin physiography and the composition/nature of basement in the sedimentary and petrologic variability of shallow-marine transgressive sandstones.

Modelling the spatial variability of fluvial architecture in distributive fluvial systems

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Distributive fluvial systems (DFS) are characterised by a radial distributive channel pattern in which channelised flow dissipates downstream, and exhibit a series of distinctive and quantifiable spatial trends. The deposits of these systems typically display a progressive decrease in channel dimensions, abundance, and amalgamation downstream, alongside a downstream decrease in grain size and an increase in floodplain and splay elements. While these characteristics of distributive fluvial systems have been studied in depth, reservoir models depicting the spatial variations of these systems are limited, despite the fact that the three-dimensional relationships between the architectural elements can significantly impact reservoir characterisation.

This study examines the spatial distribution and downstream trends displayed by the Lower Jurassic Kayenta Formation of south-western USA, and highlights the processes needed to build reservoir models from virtual outcrop models of distributive fluvial systems. Virtual outcrop models were collected at key locations from proximal to distal, to analyse the sedimentary architecture and collate statistical and geometrical data of the fluvial architectural elements.

Within the Kayenta fluvial deposits, a clear decrease in channel and splay amalgamation and a small decrease in grain size downstream are observed, as well as an overall increase in the percentage of floodplain depositional elements downstream. Reservoir models and flow simulations were produced from the virtual outcrop models depicting the downstream variation in sedimentology and highlight how the changes in sedimentary architecture can affect fluid migration through preserved ancient distributive fluvial systems, aiding in our understanding of reservoir characterisation for both hydrocarbon and CO_2 storage potential.

Evolution of submarine channel-mouth settings in tectonically-active rift settings: the Oxfordian Heather Formation, northern North Sea

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Deep-marine channel mouth settings are transient features with a poor preservation potential in the stratigraphic record due to the propagation of feeder channels. However, they are sites of abrupt changes in sediment gravity flow processes, and establishing recognition criteria in different tectonic settings is crucial to improved understanding of deep-water systems. A rare subsurface example of channel-mouth stratigraphy, and associated channel-fills and frontal lobe deposits, across syn-rift fault-related topography is documented in the turbidites of the Late Jurassic Heather Formation.
Five cored wells (total thickness of 330 m) permit construction of a 4 km long strike correlation panel, enabling detailed correlation of biostratigraphic constrained units (late Early to late Middle Oxfordian). The stratigraphic architecture and seismic interpretation across a 10 x 10 km area, including detailed RMS amplitude attribute maps, enable the palaeogeographic reconstruction of the system that prograded northwestward, consistent with palaeoflow directions derived from core image logs. This study highlights the stratigraphic organization of channel-fills, channel-mouth deposits, and frontal lobes deposits, in a topographically complex syn-rift setting, detailing characteristics of proximal, medial, distal channel-mouth facies associations and related key facies and bedforms (scour fills, dune-scale bedforms with potential backsets, low-amplitude bedwaves, reflected/deflected rounded ripples, fluid mud deposits, debrites, slumps and slides).
Initial development of sandy fairways in topographic lows is recorded during late Early Oxfordian, with progradation of sandy channel-fills across frontal lobes. Subsequent eastward migration of sandy fairways with slope tilting, is associated with development of frontal lobes and mass wasting deposits downdip of channel-mouths, and subsequent propagation of coarse-grained channel-fills and channel-mouth deposits. These results have implications for identification of channel-mouth deposits in syn-rift settings that can be used for palaeoenvironmental interpretations in other tectonically-active slopes, helping their recognition in outcrop or core datasets given the paucity of documented examples in modern and ancient systems.

Variations in tectonic activity of the Menilite-Cergowa basin (Oligocene, Outer Carpathians) reflected by hybrid event beds (HEBs)

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Hybrid event beds (HEBs) are thought to indicate seafloor topographic disequilibrium of profile of the submarine slopes down which sediment density flows carry their load into deep basins. Tectonic movements of the basin floor result in irregularities responsible for disequilibrium, whereas erosion and sedimentation promote equilibrium of the slope system. The synorogenic succession of the Cergowa Beds (Lower Oligocene; the Outer Carpathians) overlies anoxic facies of semi-starved Menilite Beds basin, and was deposited by a range of sand-rich sediment gravity flows during two nannoplankton zones NP 23 and NP24. The stratigraphic sections representing these two age intervals differ remarkably in the proportions of the contained hybrid event beds. The section of the NP23 zone is characterised by relatively frequent HEB occurrences. Their proportions range from 8% in the facies associations interpreted as lobe axis and proximal fringes, to 25% in the middle and distal lobe fringes. The succeeding strata of the NP24 zone are lacking HEBs altogether. These differences in HEBs content suggest that tectonic quiescence preceding the Cergowa Beds deposition was followed by tectonic activity and substratum deformations resulting in topographic disequilibrium of the slope during the NP23 zone. The resulting erosion of elevations, probably blanketing of depressions by sedimentary compensation, and/or rate of deposition exceeding the rate of tectonic deformation, enabled the equilibrium profile of the palaeoslope to be reached and persist during the NP24 zone. This is documented by the absence of HEBs in the deposits of this zone.

Upwelling-related ironstone, Phanerozoic ocean oxygenation, and biologic evolution

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Ironstone is a Phanerozoic marine bioelemental sedimentary rock containing >15 wt.% Fe. Unlike Precambrian iron formation, which generally forms larger deposits with a more complex Fe mineralogy, ironstone occurrences are smaller, aluminous, and composed primarily of hematite, berthierine, and chamosite. Deposition peaked in the Ordovician to Devonian and Jurassic to Palaeogene. These periods of enhanced accumulation have historically been linked to a greenhouse climate, increased chemical weathering, and transport of Fe to the global ocean. Problematic is that continentally derived Fe is insoluble in oxygenated coastal environments and therefore unavailable for the precipitation of ironstone.

Recent research provides new insight into the 'ironstone paradox'. Many Palaeozoic and Mesozoic ironstones co-occur with the upwelling triad of phosphorite, chert, and organic-rich mudstone. Ironstone parasequences generally accumulated near storm wave base and commonly coarsen from unbioturbated, pyritic mudstone through variably burrowed phosphatic and berthierine-rich siltstone that is capped by hummocky cross-stratified sandstone and cross-stratified granular ironstone. Elevated Eu in granular ironstone suggests precipitation was stimulated by coastal upwelling that periodically tapped anoxic bottom water enriched in hydrothermal Fe. Paleogeographic reconstructions indicate that the production and ponding of ferruginous seawater probably occurred in restricted basins and seaways with active spreading.

This style of Fe accumulation is interpreted to record tipping points in the oxygenation history of Phanerozoic seawater. Palaeozoic ironstone documents the protracted ventilation of bottom water that began in the late Neoproterozoic and ostensibly ended in the Devonian. Mesozoic ironstone generally coincides with Jurassic and Cretaceous oceanic anoxic events that punctuated an otherwise well-ventilated ocean. Periods of biologic extinction also broadly correlate to upwelling of these anoxic waters, which in addition to Fe were enriched in toxic, redox sensitive trace elements. Thus, precipitation of upwelling-related ironstone may have been an important negative feedback process that sequestered these elements, aiding in post-extinction recovery.

The Horse Latitudes Favor Non-Skeletal Marine Carbonates

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In the Modern oceans, temperature, turbidity, and saturation state deliver an antithetic relationship between reefs and non-skeletal carbonates, including whitings and ooids, with profound implications for the variation in the style of carbonate platforms with latitude. Ancient platforms were likely similarly controlled. Appropriately sized platforms in the horse latitudes are predisposed to copious mud production through whitings, a phenomenon which will incline them towards non-rimmed 'Bahamian-type' morphologies, quite unlike the underfilled and reef-rimmed platforms of the tropics. We developed a 15-year record of Bahamas whitings combined with a sea surface temperature timeseries, plus simulations of platform-top hydrodynamics and chemistry. These data demonstrate that, on Great Bahama Bank, an interplay between hydrodynamics and water temperature serves to focus the whitings mud factory into an area of only 1% of the entire platform. Furthermore, whitings are more numerous and larger in winter than summer, a finding in opposition to thermodynamic expectations. We propose a three-step process to explain these observations. First, temperature differentials between on- and off-platform waters are highest in winter, setting up a disparity between dissolved CO2 concentrations in the two water masses. Second, hydrodynamic mixing increases the degree of aragonite saturation of the platform-top waters, and thus carbonate precipitation rates, as colder on-platform waters with higher concentrations of dissolved gases are warmed via mixing with the warmer off-platform waters. Finally, spatial heterogeneity in aragonite saturation is higher in winter, and the zone of peak whitings is situated in an area of locally-enhanced saturation state proposed to increase whitings precipitation. Our hypothesis pitches temperature and hydrodynamics to act in unison to localize predominant modes of grain production. This forcing might have fundamental implications for understanding facies distributions in the rock record, but perhaps also to understanding the latitudinal variation of platform architecture which spans tropical reef-rimmed to sub-tropical open margins.

Sedimentological controls on the petrology, petrophysics and petrothermics of salt-embedded basins: the sedimentary succession of the Estopanyà and Boix synclines (South-Central Pyrenees, NE Spain)

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The Estopanyà and Boix synclines are two salt-embedded structures in the South-Central Pyrenees within the Serres Marginals thrust sheet (NE Spain). From the Upper Cretaceous to the Oligocene, the Alpine orogeny produced the nucleation, inflation, extrusion, and welding of two salt walls adjacent to these synclines modifying their sedimentary dynamics. In this contribution, we present the petrophysical and petrothermal analysis of the synorogenic sedimentary succession of the Estopanyà and Boix synclines to decipher how sedimentology affects the petrology, petrophysical and petrothermal properties of the basin-infill units.

103 rock samples were collected consisting of carbonates, sandstones, breccias, and conglomerates. Samples were clustered into three lithological groups and eight facies attending thin-section description and their sedimentological attributes: 1) carbonates (lacustrine mudstones-wackestones, marine and palustral packstones-grainstones, breccias, and edaphic facies); 2) sandstones (fluvial hybrid to detrital, deltaic bioclastic, and edaphic facies); and 3) chalks in the centre of the Estopanyà syncline.

The petrophysical and petrothermal data was acquired from 77 rock cubes (39 samples) and 107 rock slices (57 samples). Petrophysical results reveal well-clustered mineral densities (2.64-2.72 g/cm3), whilst variable connected porosity (0.50-17.63 %), permeability (0.001-15.30 mD), and seismic velocity values (1777-6560 m/s for dry and 2701–6344 m/s for water-saturated values). The highest porosities belong to chalks followed by sandstones and carbonates. Permeability values show that sandstones are more permeable than carbonates and chalks. Conversely, P-wave velocities are faster for carbonates than for the other lithological groups. The thermal conductivity (2.059-4.685 W/mK) of the studied succession is independent of petrophysical properties or facies.

Porosity plays a key role in the observed petrophysical variation. The sedimentary textures and structures such as laminations, inherited from the depositional environment and alteration, strongly influenced the pore-space distribution and its connectivity, underlying the importance of sedimentology and early diagenetic alteration on the reservoir quality of these salt-embedded basins.

The diagenetic evolution of the Cretaceous Kawagarh Formation in the Attock Hazara Fold and Thrust Belt, Pakistan

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The Kawagarh Formation exhibits a unique library of marine, sedimentation, diagenetic, climatic, and tectonic records, with recent hydrocarbon discoveries emphasizing the importance of sedimentology, particularly diagenesis, for reservoir characterization. This research aims to reconstruct and describe the various phases of diagenesis and their sequence in the shallow ramp carbonates of the Kawagarh Formation.

Through outcrop, petrographic, and geochemical analyses, the study identifies and characterizes diagenetic processes such as early calcite cementation, dolomitization, compaction, and calcitisation. Early calcite cementation is found to occur during marine burial diagenesis, originating from pore fluid dissolution of aragonite in interlayer marl/mudstone beds and reprecipitation as microspar in adjacent limestone beds. Dolomitization with stylolites and negative oxygen isotope values suggests a fault-related hydrothermal dolomitization model.

The study also highlights the presence of calcitisation in shallow burial settings due to fractures and low magnesium fresh fluids introduced by uplift. Mixing of surface-derived waters with hot burial fluids during calcitisation is indicated by depleted carbon and negative oxygen isotope values. The findings provide insights into burial depths, fluid influx, geochemical gradients, and reservoir properties such as porosity and permeability.

Microplastics and rock-like plastic pollution as sedimentary components in coral reef systems

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Microplastic pollution is pervasive in coral reef systems across the tropics, adversely impacting coral health through bleaching, tissue necrosis, and immune system impairment. Simultaneously, unregulated plastic waste disposal contributes to the formation of pyroplastics and plastiglomerates—"rocks" comprised of natural elements and melted plastic. Microplastics and plastiglomerates form from a wider variety of plastic polymers such as polyethylene and polypropylene (PE/PP) but also acrylates/polyurethane/varnish (PU), which determine their unique properties. We demonstrated based on work in Indonesia and the Mediterranean, that microplastics and plastiglomerates are becoming a significant component in reef sediments. Microplastics, predominantly secondary and derived from local sources, exhibit similar transport and accumulation behavior as fine siliciclastic grains. Proximity to important plastic debris sources and hydrodynamic processes influences microplastic abundance and distribution. Reef sediments act as a permanent sink for microplastics, with accumulation facilitated by biofouling, interlocking, and compound grain formation. The transport behavior of pyroplastics and plastiglomerates in turn depends on the ratio and type of polymers. Pyroplastics are typically buoyant, while plastiglomerates are not. Coastal ecosystems worldwide, will be increasingly affected by microplastics and plastiglomerates, transferring organic pollutants to marine organisms and negatively impacting ocean health. We demonstrate that sedimentary methods can help evaluating this risks, which will contribute to adequate management strategies.

Ultimate tidalites preserved in the lee of polder dikes: findings from geoarcheological surveys in the French Flemish coastal plain

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Surface conductivity, ground-penetrating radar (GPR), and archeological pit exposures provide elements for documenting dike breaches in the medieval polders of the Denna estuary (SW Dunkerque). Conductivity maps reveal mud-filled ponds preserved along the medieval dikes. GPR profiles show that these ponds overlie the apex of sand splays forming the last polder deposits. Below the ponds, the sand infills 3m-deep scours floored by a mud breccia reworked from the collapsed walls of the scour. Low-angle truncations and traction carpets of mud clasts inset in the sand suggest it was deposited by high-velocity sheet flows. The overlying mud, channelized into the sand, is composed by bundles of sand-mud couplets, interpreted as semi-lunar tidal cycles. The proposed interpretation is that each of those ponds point to a dike breach created by an overflow event. The overflow scoured a plunge pool, and splayed a sand sheet in the polder. In vicinity of the breach, the sand was channelized by backwater flow. The residual blind channel then evolved as a pond progressively infilled by tidalites. The number of preserved tidalites implies that the pond infilling may have been completed within 3 years, and the locally centimeter-thick sand-mud couplets suggest that turbidity of the incoming water remained high during that time. The preservation of 12-14 couplets per bundle indicates that the pond could be flooded by 50% of the highest tides only (ca. spring tides). This is consistent with the present-day levels of the tide at the coast, considering the elevation of the preserved tidalites and supposing that no subsidence occurred, which is most likely in this area devoid of peat. The sandiness of the sand splay, contrasting with the muddiness of the overlying tidalites, suggests that the breach was formed during a major storm, causing massive resuspension of the sandy sediments in the estuary.

Deciphering the early-stage evolution of relict marine basins: the case of the Ceahlău-Severin Ocean of the Romanian Carpathians

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Opened since the Middle Jurassic as a branch of Alpine Tethys, the Ceahlău-Severin "Ocean" was traditionally defined based on poorly characterized “ophiolites” associated with Upper Jurassic-Lower Cretaceous sedimentary formations (Sinaia and Black Flysch Units), later incorporated into the Carpathian Orogen, during the Cretaceous thrusting phases. Early-stage evolution of the basin is still unclear since most of its crust has been consumed by subduction commencing in the Early Cretaceous. The lower Member of the Sinaia Formation consists of Upper Jurassic shales, marlstones, cherts, and thin sandstones. Its lateral variation, the Azuga Member, includes red shales with radiolarians. Collectively, these sediments suggest pelagic/hemipelagic suspension settling, carbonate, and siliceous productivity alternating with low-density turbidite currents on the basin plain. Basalts and serpentinites occur in the Azuga Member, but most of the stratigraphic relationships are obliterated tectonically. Locally in the Southern and Southeastern Carpathians, pillow basalts in conformity with the sedimentary stratification can be interpreted as intraformational submarine lava flows. Likewise, in the northern part of the Eastern Carpathians, basalts from the Black Flysch Unit display intimate stratigraphic relationships with Oxfordian-Tithonian deep-sea limestones. Whole-rock REE and Ta/Yb–Th/Yb systematics indicate that the basalts are confined to the global MORB array and reflect various degrees of melting of their mantle source along oceanic ridge segments with different spreading rates. According to this systematics, N-MORB-like basalts from the Southeastern Carpathians formed along a fast-spreading oceanic ridge, whereas E-MORB-like basalts from the Southern Carpathians reflect a slower spreading regime. OIB-like basalts from the northern segment of the Eastern Carpathians, suggest low-degree mantle melting beneath a thicker - possibly continental - lithosphere.
Our data sustain that the variable expansion rates along the rift system were sufficient to accommodate deep-sea plain deposits and thin turbidites preserved in the Southern and Eastern Carpathians. This work was supported by project PN-III-P4-PCE-2021-0901.

Visualising low enthalpy geothermal favourability in Scotland: A map-based screening tool for community scale open-loop ground source heat pumps in superficial aquifers

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The Climate Change (Emissions Reduction Targets) (Scotland) Act 2019 demands a net zero economy in Scotland by 2045, yet in the same year over three quarters of domestic heating was met by natural gas. A novel method and dynamic map resource is developed to visualise low enthalpy geothermal potential for space heating on a community scale using Ground Source Heat Pumps (GSHPs) and District Heat Networks (DHNs). This resource is intended to provide a screening tool that enables communities and policy makers to effectively reduce carbon emissions by aiding early-stage decision making and understanding of geothermal potential within the context of their communities.
ArcGIS software is used to infer geothermal potential in 49,768km2 of superficial deposits (64% of total land area), in Scotland, using a Favourability Index (FI) and a 1km2 grid. Cells are assigned an FI value (0.0 - 5.0) using ten metrics based on key criteria: 1) deposit coverage, 2) thickness, 3) aquifer productivity, 4) temperature, 5) ground conditions, 6) heat demand, 7) protected land. Map resources developed show lowland areas generally exhibit more favourable conditions particularly within the Midland Valley, and settlements predominantly lie in high favourability areas. ~60% of the population is identified as living in areas where further investigations into community scale GSHPs is warranted, suggesting that the thermal resource held in unconsolidated sediments has significant potential to decarbonise the Scottish heating sector.

Assessing controls on clinoform geometries from outcrop studies

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Clinoforms are fundamental building blocks of sedimentary geology, developing across various scales and timelines. Smaller ripples and dunes merge to form larger depositional features, which in turn supply the shelves and continents with sediment. The dynamic system of compound and hybrid clinoforms splitting and merging as accommodation and sediment supply wax and wane, forms the fundament for sediment delivery to the marine realm and thus many basin reservoirs. While clinoforms often display a typical s-shaped geometry, with a flat topset, sloping foreset and gentle bottomset, the size, slope and curvature of clinoforms varies significantly across scales and between depositional environments. There are clearly fundamental processes in place controlling how clinoforms develop, while also specific environments, lithologies, sediment supply rates and depositional processes contributing to the variation. Given the scale of many clinoform systems, the study of their geometries has often been carried out on seismic data. The present study is based on extensive photogrammetric outcrop models combined with logging, in order to extract clinoform geometries and include detailed information on their facies lateral variability. This work investigates several clinoform systems of different ages: The Ediacaran Bonney Sandstone Formation (Adelaide Rift Complex), the Upper Cretaceous Star Point Formation (US Western Interior), the Upper Cretaceous Rock Springs Formation (US Western Interior), the Upper Cretaceous Blackhawk Formation (US Western Interior), the Eocene Sobrarbe Formation (Ainsa Basin), and the Eocene Roda Sandstone Formation (Tremp-Graus Basin). These are all shallow marine low angle prograding systems with deltaic to shelf-scale clinoforms (several 10s to a 100 of m of relief), and some include nested smaller-scale clinoforms (mouth-bars). The project will explore the degree of predictability that may exist between sedimentary processes and lithologies, and the resultant clinoform geometries.

Architectural element scale heterogeneities of deep-water rocks and their influence on CO2 injection, migration, and storage.

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Reservoirs within deep-water rocks are well understood for hydrocarbon production, but specific parameters important for CO2 storage are less well constrained. Previous research has shown that reservoir heterogeneity is beneficial, as intra-formational baffles will increase the available surface area for CO2 to react with the reservoir. However, these works have principally been concerned with permeability contrasts between net reservoir and the intra-formational baffles. The presented work focuses on the thickness and lateral extent of these heterogeneities and how they will influence CO2 migration and storage, with reference to realistic reservoir stacking geometries obtained from subsurface and outcrop data.

This work utilises an extensive dataset, integrating seismic, well-log, production, and core data from a subsurface deep-water fan system to investigate architectural element scale heterogeneities in the context of CO2 injection and storage. The scale of heterogeneities in this work ranges from silt/mud tops of singular, dilute turbidity currents, with thicknesses of a few centimetres, and lateral extents of metres of 100s of metres, up to fine-grained packages separating lobe complexes, with thicknesses of metres to 10s of metres, and lateral extents of 100s to 1000s of metres. Here, we use numerical simulations of injection to test the suitability of different parts of these systems for CO2 storage. Models and simulations are created and run using Petrel and Eclipse software packages, respectively. Preliminary results show that axial medial lobe architectural elements are the most suitable part of these systems, as they provide the optimal balance between net reservoir and intra-formational scale heterogeneity. We demonstrate the varying suitability of reservoirs made up of deep-water fan deposits while also adding to current understanding of how baffles and barriers play a significantly different role for CO2 injection and flow than for conventional hydrocarbon extraction.

Tectonostratigraphic Controls on a Syn-rift Triassic Distributive Fluvial System: New Insights from the Tampen Spur area and Adjacent Regions, North Sea

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For over 40 years, the North Sea region has remained a mature area for hydrocarbon exploration with various world-class oil and gas discoveries. Recent interest in the continental Triassic reservoir successions coupled with up-to-date preliminary results from palynology and heavy mineral studies have prompted a re-examination of the tectonostratigraphic evolution of Triassic basins in the North Sea. In the Tampen Spur area, Snorre, Visund, and Gullfaks constitute the main fields with Triassic reservoirs. Previous studies have focused on lithostratigraphic correlations and at a field scale within a limited tectonostratigraphic framework. To reduce risk and enhance understanding of the Triassic succession, we aim to reconstruct Triassic depositional systems and basin-scale architecture through time.

Age-constrained tectonostratigraphic approach suggests that rifting ceased by the end of early Triassic and affected primarily the south-eastern margin of the basin with minor influence on drainage. Salt anticlines developed in Permian evaporites down-dip on major faults and can be traced by 2D and 3D datasets. However, there are no signs of mini-basin development. Provenance studies indicate that Fennoscandia Shield represents the main sediment source for the entire 1.5 km Triassic interval. The lack of active fault movement during sedimentation suggests that deposition is largely climatically controlled.

Detailed analysis of core and analysis of wireline logs calibrated to core suggested deposition in fluvial channel, floodplain, and splay settings. On the Tampen Spur, major progradational and retro-gradational motifs can be identified in the 1.5 km thick sedimentary succession between the early and late Triassic. Mapping of depositional systems suggests deposition as part of a single or series of distributive fluvial systems that prograded westwards from a Norwegian source area.

These preliminary results enlighten the spatial and temporal variability in the structural and sedimentological development of Triassic basins allowing detailed paleogeographic reconstruction within a newly established chronostratigraphic framework.

Investigating Geochemical Biosignatures in Low-Temperature Carbonates: Laboratory and Field Studies

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Carbonates are ubiquitous in the geologic record over Earth's history and are found on Mars and within meteorites. The chemical and isotopic compositions of such carbonates have been used to constrain the composition of ancient oceans and the prevailing conditions during the development of life and its subsequent rapid evolution. Carbonate mineral compositions reflect the environmental conditions under which they were formed. Recent studies have shown that microorganisms can produce carbonates with a geochemical signature that differs to those formed abiotically. Our work integrates field studies, state-of-the-art laboratory experiments, mineralogical and geochemical analysis to investigate the processes and environmental conditions that control the chemical composition of low temperature carbonates. The role of inorganic-organic interactions is evaluated in a natural field laboratory and carefully controlled laboratory experiments performed under abiotic and biotic conditions. Mg- and Fe-rich carbonates therefore appear to represent a robust proxy of biological activity that can be used to determine the specific environmental conditions for formation of Terrestrial and Martian carbonates.

Disconformities in the Precambrian Rock Record and Their Interplay Among Pedogenesis, Erosion, and Crusts: The Example of the Capiru Group, Brazil

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The Neoproterozoic Capiru Group (SE-Brazil) records a passive continental margin now enclosed in the Brazilian - Pan African southern Ribeira belt. One of the most recognizable features of this stratigraphic archive is a regional disconformity. The surface is Pre-Brazilian/Pan-African in age, where the related weathering cycle gave rise to a paleosol profile on the continental domain and a karstic paleotopography on an emerged carbonate shelf. The exposed surface and the karstic nets were later caped and filled with Al-rich materials, typical of remobilized soils and Fe- and Al-rich duricrusts, bauxitic clays, clayey bauxites and pods of karst-type bauxites.

These deposits and reworked crusts show a complex interplay between remobilisation of pre-existing kaolinitic soils and depositional micro-environments. In this system, we investigate the relationship among the disconformity, paleosol development, and karst topography to better understand its stratigraphic control, the chemical, and mineralogical compositions of these Fe- and Al-rich materials.

We interpreted this horizon as the remnants of a (meta-)paleoweathering surface that can be used as a maker bed for stratigraphic correlation and in paleogeographic reconstructions.

We propose that the triggering process for the genesis of the paleosols, bauxitic material and duricrusts was a coupled mechanism between favourable climate and uplift along the northern margin of the Curitiba–Angola craton, developing a karstic topography that allowed the down-plain transport of weathered materials.

In a later stage, these deposits were metamorphosed, developing a series of Al silicates in unusual paragenesis, typical of Al-rich protoliths.

The presence of these paragenesis, along with the recognition of the disconformity–paleoweathering surface pair, could be a useful tool to understand the paleoenvironmental and paleogeographic evolution of highly deformed and ancient terrains.

Diverse progradation styles and paleo-storm indicators within subtropical coastal strandplains

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We present a decadal field research dataset from Holocene strandplains along the Gulf Coast of Florida (Cayo Costa, North Captiva, and Sanibel islands) and The Bahamas (Little Exuma, Eleuthera, and San Salvador islands). Given common anthropogenic development over strandplains and the incipient lithification of carbonate-rich bioclastic sequences, limitations of traditional coring and trenching can be overcome with high-resolution ground-penetrating radar (GPR) imaging. Shore-normal surveys reveal diverse styles of beach progradation (berm/beachface accretion) and penecontemporaneous dune aggradation. In contrast to gently sloping (<10^{o}) offlaping clinoforms representing fairweather accretion, storm-related features include steep truncations (20-90^{o}). Many distinct beach/dune sets are nucleated on steep scarps (swash-aligned disconformities) produced by storms. Foredune bases and berm crests, recognized by inflections in GPR reflectors, rather than dune tops, serve as markers of regional high-tide (and by extension, sea-level) positions. Some swales may contain overwash deposits of variable thickness and extent. Narrow back-dune basins may preserve a full overwash/overtop lithosome, represented by landward-dipping clinoforms that extend from a paleo-dune of one ridge set (landward offlap) to an older set (landward onlap). In mixed carbonate-siliciclastic beaches of Florida, mineralogical anomalies may accentuate paleo-event horizons and serve as potential strong reflections in radargrams. In fully carbonate settings (The Bahamas), buried reef and beachrock rip-up clasts generate point-source diffractions, which complement other event indicators. Some animal traces (sea turtle nests, crab and shrimp burrows) within beach and dune ichnocoenoses serve as independent indicators of (paleo-)water/sea level and aid in recognition of disconformities or omission surfaces. Our findings show that Holocene strandplains serve as rich archives of cyclone (and occasional tsunami) impacts in subtropical regions. Such revelations of Holocene strandplain history can provide opportunities for better management of coastal resilience.

Downslope evolution of supercritical bedforms in a confined deep-sea fan lobe, Amantea Fan, Paola Basin (Southeastern Tyrrhenian Sea)

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The sedimentology of upper flow regime bedforms represent an important research topic. Deposits of supercritical flows are widely recognized in modern fan system, but their sampling is challenging. Most of the sedimentological information came from channel talwegs, but supercritical bedforms are frequent also in the channel-mouth environment. Such an environment has been identified in the Paola basin, where erosive and depositional cyclic steps have been imaged and sampled in a sandy submarine lobe of the Amantea Fan. High-resolution sub-bottom profiles provide insight into the internal architecture of the bedforms and their relationships with a frontally-confining ridge. For the first time, supercritical bedforms in a submarine lobe have been sampled in two distinct positions: in the scour of an erosional cyclic step and in the stoss side of a depositional cyclic step. Coarse- to medium-grained massive sand with flame structures, generally associated with the occurrence of hydraulic jumps, has been identified in the scour and at the toe of the ridge. The latter finding represents an example of a topographically induced hydraulic jump driven by a frontal confinement. Fine, top-cut-out sand with tractive structures has been sampled on the stoss side of a cyclic step recording the passage, after the hydraulic jump, to the subcritical phase. Our data broaden the understanding of the range of processes that are driven by the interaction between turbidity currents and seafloor topography and the dip of the slope. The recognition that topography affects the density structure and the degree of criticality of the flow and, consequently, the morphodynamics and facies of the relative deposits may help to explain sediment distribution and improve depositional models of fan lobe in confined settings.

Eustatic and tectonic controls on mixed clastic-carbonate deposition in the South Pyrenean foreland: the Eocene Alveolina Limestone

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The Paleocene-Eocene depositional systems in the South Pyrenean foreland (Spain) were influenced by eustatic sea level changes, active tectonics of the Pyrenean orogeny, as well as biotic and environmental changes during the Paleocene-Eocene Thermal Maximum (PETM). This study combines outcrop observations and microfacies analysis to derive a depositional model and to evaluate the relative roles of these factors during deposition of the Early Eocene Alveolina limestone, which postdates the PETM. The Alveolina limestone is preserved in the footwall of the Montsec thrust. Facies variations relative to the structure and thickness variations suggest deposition at least partly during active thrusting and/or salt tectonics.
Depositional environments ranged from coastal plain to a shallow-marine mixed carbonate-siliciclastic ramp influenced by tidal processes. A local barrier system of tidal bars separated a lagoon from fully open-marine environments. Facies are rich in large benthic foraminifera likely due to global highly oligotrophic conditions succeeding the PETM. Foraminifera in the Alveolina limestone represent distinct environments from nearshore to middle/outer ramp. Outcrops distal to the Montsec thrust preserve a relatively complete section, which forms part of an overall transgressive succession from continental Paleocene to open marine Eocene strata. An encrusted hardground and glauconitic horizon in the upper Alveolina limestone record sedimentary condensation. The overlying Baronia sandstone is dominated by mixed to siliciclastic-dominated compound tidal dunes. The change in lithology and bar form type reflects increasing siliciclastic input into the basin and possibly a different tidal regime during an ensuing regressive phase. In proximity to the Montsec thrust, the Alveolina limestone thins from 55 to 35 meters, and is only represented by carbonate beach deposits interbedded with carbonate debrites and sandstones. These were likely derived from Mesozoic strata exposed nearby. This succession reflects lower accommodation space and higher detrital input near the Montsec structure.

Detecting the composite nature of shallow water terraced marine deposits throughout key sedimentary facies and their relationship.

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Terraced marine deposits are sedimentary bodies developed during sea-level highstands on a wave-cut platform. Peculiar high-frequency sea-level fluctuations and tectonic activity interactions may lead to multiple sea transgressions within the same marine terraced deposit, better known as composite marine terraces.
For shallow water cliff-bounded pocket beach systems, the composite nature of the observed sedimentary successions is relatively complicated to recognise due to their ephemeral character and flexibility in adapting to rapid change. Moreover, these systems are characterised by a wide range of sediment textures that can range from sandy to gravelly, from mixed siliciclastic to a combination of algae bioconstruction and siliciclastic deposition, and their depositional architecture is highly dependent on sediment supply and cliff nourishment.
Thus, high-frequency sea changes may be recorded by pocket beaches not only by the variation in the beachface (progradation and aggradation) but also by the development of distinctive facies that mark different phases, such as the initial sea ingression with erosion during transgression (pothole facies, gravel lag), deposition occurred during sea stability (beachface and berms, bioconstruction), slow sea rising (beach prograding or algal bioconstruction) or subaerial exposition (duricrust, thin colluvial or paleosol).
All these key facies and their combination might be used to detect the composite nature of surfaces and highlight multiple phases of pocket beach development under small relative sea level variations. Hence, pocket beaches are a powerful archive for detecting rapid sea fluctuations and coastal tectonic activity along rocky coasts.
In this work, we explore all the different sedimentary facies, describing their textural character depositional features and interpretation to distinguish composite terraced from a single one formed in a very shallow water setting.

Integrated characterisation of Cretaceous turbidites systems reworked by bottom currents along the mid-Norwegian Margin.

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Studies of ancient deep marine sediments show that outcrop and core interpretations are often ambiguous and sometimes fail to recognize hybrid depositional systems associated with sediment gravity flows and bottom currents. However, very few studies utilize an integrated approach including tectonics, paleobathymetry, and associated oceanographic processes that collectively provide a more robust basis for recognizing ancient hybrid systems.

This study documents Cretaceous bottom-current related erosional and depositional features (moats, channels, furrows and drifts) along the mid-Norwegian Margin; and demonstrates the importance of applying regional three-dimensional seismic analysis to identify the origin of these kilometre-scale features.

Seismic-scale features are defined by a series of elongated drifts successively onlapping a paleo-slope while characterised by lateral amplitude variations from relatively high amplitude in the up-dip erosional moat to decreasing amplitudes towards the down-dip part of the drift. Nearby seismic well-tie shows the presence of sand-rich intervals, as well as direct relationship to downslope turbidite systems. Regional tectono-stratigraphic and oceanographic reconstructions coupled with the spatio-temporal evolution of the elongated drifts strongly suggest the interaction between gravity flow and bottom currents. This interaction could manifest as anything from surface currents in relatively shallow settings, to deep tidal currents on paleo-terraces, or thermohaline circulation along the paleo-slope. Additional integration with sedimentology, biostratigraphy, ichnology and petrography is instrumental to understand the origin and variability of bottom currents across the basin. Ultimately, recognition of ancient bottom-current processes in the rock record can provide significant insights into paleoclimatic and paleoceanographic processes with implications far beyond their economic importance.

Widespread wildfires linked to early Albian Ocean Anoxic Event 1b: Evidence from the Fuxin lacustrine basin, NE China

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Wildfires are an important source of disturbances in the Earth's system and are of great significance for understanding the interactions between environmental, atmospheric and vegetation changes over deep time. The early Cretaceous was a "high-fire" interval with frequent and widespread wildfires globally. We undertook a multi-proxy study evaluating kerogen macerals, inertinite reflectance, and polycyclic aromatic hydrocarbons (PAHs) from mudstones to characterize wildfire activity in the Albian coal-forming Fuxin lacustrine Basin, and correlate these with (i) environmental and floral changes on land, and (ii) well-dated marine events including the early Albian Oceanic Anoxic Event 1b (OAE 1b), to consider their environmental and climatic significance. The presence of high inertinite contents demonstrate that multiple, widespread wildfire events occurred during the early Albian, which are correlated stratigraphically to the Kilian, Paquier and Leenhardt sub-events of the early Albian OAE 1b. Inertinite reflectance values ranging from 0.6% to 3.8%Ro show that wildfires in the early Albian were dominated by ground fires, with a smaller proportion of surface fires and almost no crown fires. Atmospheric oxygen concentration (pO_2) levels, estimated from inertinite contents, attained ~25% during the early Albian, which exceeded the present atmospheric oxygen level of 21% and was able to support sustained combustion. Climatic conditions and frequent wildfire activity in the early Albian might have acted as an important control on vegetation distribution and diversification during the early Cretaceous. Wildfire activity resulted in the burning and destruction of both vegetation and soil structure, enhancing the post-fire erosion associated with intensified continental weathering under warmer and more humid conditions during the early Albian OAE 1b interval. These episodes of high wildfire activity correlate with high nutrients and organic matter levels in lakes and thereby contributed to eutrophication and anoxia in lacustrine and in contemporaneous oceanic systems.

The Messinian Sedimentary record in the Sorbas Basin: insights from the Sofia 7 drill-core

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The Sorbas Basin in SE Spain is key for the study of the Messinian Salinity Crisis (MSC).Past research focused on partial sections due to the lack of continuous outcrops. The Sofia 7 core, drilled by Saint-Gobain Placo Ibérica, provides the first continuous record of MSC units in the Sorbas Basin.

The core (174.5m deep) records pre-evaporitic marls (Abad Mb) in a basin deeper than 200m, followed by five evaporitic cycles of the Yesares Mb (124.5m), showing selenitic and nodular gypsum layers, and inter-evaporitic,massive and laminated marls, interpreted to have been deposited under a water column shallower than 200m. The Sorbas Mb (34m) represents coastal facies, while the upper unit, Zorreras Mb, includes 9m of reddish sandstones and silts of continental origin above sea level.

The MSC core units have been petrographically characterized by the analysis of 26 thin sections with optical and scanning electron microscopy (SEM/EDS). Additionally, 345 samples were analyzed with X-Ray Diffraction (XRD) and X-Ray Fluorescence (XRF) to determine gypsum-marl cyclicity. Marls from the Abad Mb and inter-evaporitic levels were collected for micropaleontological analysis and total organic carbon (TOC) assessment.

Variations in total gypsum content associated with increased terrigenous minerals were identified, especially in the last gypsum cycle. Sulphate isotopic composition of 45 evaporite samples indicate late Miocene marine evaporites with sulphate-reducing bacteria activity in stratified water columns ($\delta^{34}S$ ratios >22‰). Conversely, the upper gypsum cycle yields $\delta^{34}S$ ratios <22‰, revealing continental water input. This corresponds to a reduction in the radiogenic Sr content (ppm) in the uppermost gypsum cycle, suggesting declining salinity.

The Sofia-7 core sedimentary record reveals a shallowing upward sequence along the MSC in the Sorbas Basin that we interpret as a consequence of a regression induced by the seaward movement of the shoreline in response to relative sea-level decrease.

Sediments in Watercolour – Reassessing outcrop sketches to improve interpretation in the field

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Field sketches are a fundamental tool for geoscientists in both research and learning, allowing us to document our interpretations in the field. Before photography was main-stream, field sketching and watercolours were the norm for all field researchers. Sketching allows observers take time to look more carefully as well as better communicate their findings to others. Conventional sketching focuses on the use of lines to build a representation of the outcrop and is notorious for being difficult, especially for students. When on fieldwork perspective, weather, and lighting can all distort the view -changing colours and shapes to both highlight and conceal features of interest– making it hard to capture in conventional sketches.
Here we use an interdisciplinary workflow by sketching with simple watercolour techniques in addition to digital photography, to capture field observations accurately and to spatially locate data collected. This workflow has been used during fieldwork at three sedimentary outcrops in the UK, Italy, and Switzerland. We find that the multidimensional sketches produced are clear and legible panoramas of the outcrop with geological data and measurements geospatially annotated onto the outcrop sketch. Watercolour paints are easily available in many forms and help promote the use of colour and less reliance on lines. The sketches are easy to refer to photographs and virtual outcrops away from the field. Better sketches work to make the complexities of the outcrop more legible, enabling better dialogue between researchers and adding to the resource of field data available for interpretation. By taking time to observe and sketch, we concentrate on capturing details with geological importance and promote interpretation decisions, such as the continuity of a fault, that a camera does not pay attention to. We find the combined approach outlined illuminates the geology to create a much richer dataset than a photorealistic virtual outcrop alone.

Seasonal controls on the morphodynamics of the tidal flats in a macrotidal embayment (Garolim Bay), west coast of Korea

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Deciphering sedimentation and related geomorphic changes of tidal flats remain challenging due to complex interactions of controlling factors such as tides, waves, and meteorological influence. Drone-based photogrammetry, high-precision profiling, and core analysis were conducted to characterize the interactions of physical processes that shape the tidal flats in Garolim Bay, a semi-enclosed macrotidal embayment with insignificant fluvial input on the west coast of Korea. Tidal flats transition from dune-covered sand flats through mixed flats to mud flats, flanked by high-relief gravel spits and beaches near high-tide lines. Tidal flats are incised by sinuous and dendritic channels, which are nearly stationary in the mud flats and highly mobile in the sand to mixed flats. Tidal channels migrate actively during the summertime rainy season when heavy rainfall occurs during low tides. Heavy rainfall induces surface runoff, intensifying ebb currents or seaward flow even during flood tides to produce chute cutoff and subsequent infilling of abandoned channels. Anomalously high suspended sediment concentrations indicate significant seaward sediment transport during rainfall events. Ebbwardly dipping inclined heterolithic stratification substantiates overall ebb dominance. In contrast, tidal channels remain less mobile when precipitation is negligible. The sedimentation rate inferred from the difference between digital surface models and repeated profiling suggests that tidal flats alternate between summertime erosion and wintertime deposition. This starkly contrasts with open coast tidal flats in Korea, where significant erosion occurs during winter due to heightened waves. The present study highlights seasonal rainfall-induced runoff plays a crucial role in the sedimentation and morphodynamics of tidal flats in the macrotidal embayment.

Lower Miocene regressive-transgressive sequence in the fluvial-tidal depositional system in the eastern part of the North Sea basin, northern Poland

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The Lower Miocene silliclastic succession exposed in the cliffs of the Gulf of Gdańsk, northern Poland, represents a complex set of sedimentary environments. The recognised complex facies succession is indicative of the coastal zone of the North Sea Bay. A river (or rivers) had its mouth in the study area, which was the main source of sediment reworked by wave and tidal processes. Such an assemblage of sedimentary environments is characterised by high sensitivity to eustatic sea-level changes.

A number of parasequences, which are records of the evolution of individual sedimentary environments, were found in the examined profiles. On their basis, the vertical succession of facies was established. The vertical succession of the facies from tempestites, through tidal plain sediments to fluvial estuarine channels was reconstructed. It is interpreted as a progressive normal regression. This presumably resulted from a positive sediment balance in the system. This was followed by a marine transgression highlighted by extensive wave erosion and the re-development of the tidal plain.

Biostratigraphy of the aforementioned deposits is based on pollen analysis and in a minor scale on marine phytoplankton. Analyses from the Chłapowo Cliff section (northern part of the study area) suggest that the succession represents Aquitanian and presumably lower part of the Burdigalian. Pollen sequence reveals general trend from boreal to humid-tropical assemblages. Recognized regressive-transgressive sequence is correlated with global sea-level changes from the Early Miocene.

Modelling of thermal and maturation history of the Cretaceous source rock in the deep water basin ： A case study of Santos Basin， Brazil

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The Santos Basin, Brazil, is the most oil-rich passive continental margin basin in the world's deep-water areas, with oil and gas discoveries mainly concentrated under the thick salt rocks of the São Paulo Highland (also known as the Lu-Su uplift belt). However, the thermal and maturation history of Cretaceous subsalt source rocks is poorly understood. In this study, based on the measured temperature data, 2D seismic data and logging data, the BasinMod 1D, BasinMod 2D, and Basinview software were used to simulate the geothermal field and maturation of the Cretaceous source rock. Results show that the Santos Basin has mainly experienced three periods of peak heat flow since the early Cretaceous period. The first period of peak heat flow occurred during the deposition of the Picarras-Barra Velha Formation, with a value of 75~82 mW/m2; the second period of peak heat flow occurred during the deposition of the Ariri-Florianoplis Formation, with a value of 79~87 mW/m2; the third period of peak heat flow occurred during the deposition of the Santos Formation to the present day, with a value of 48~56 mW/m2. There are significant differences in the thermal maturity of source rocks in the uplift and depression areas. At the end of Ariri Formation period, the Cretaceous Itapema Formation (ITP) source rock in the western depression reached a maturity of 0.7% and entered the oil-generating stage. At the end of Florianoplis Formation period, the ITP source rock in the western depression reached a maturity of 1.8% and entered the high-maturity stage; while in the eastern depression it reached a maturity of 1% and entered the oil-generating peak stage. Currently, the ITP source rock in the western depression has a maturity of 3%, while in the eastern depression it has a maturity of about 2%, both entering the over mature stage.

NEW INSIGHTS INTO THE STRATIGRAPHIC EVOLUTION OF THE TRIASSIC FLUVIAL SUCCESSION IN THE UTSIRA HIGH AREA, NORTHERN NORTH SEA.

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Due to the multiphase rift development and the resulting complex tectonostratigraphic architecture, the Triassic succession of the Northern North Sea is an exceptional case study for understanding syn- and early post-rift continental fluvial stratigraphy. Enclosed between the Permian anhydrites and Jurassic open-marine sediments, the Triassic fluvial succession was deposited in a semi-arid continental basin. Located in the Norwegian Northern North Sea sector, the Utsira High and nearby basins are in a key location to understand the interplay between tectonics and climate in influencing the stratigraphic succession.
The paleo-geomorphological setting of the Triassic across the Northern North Sea is still poorly constrained and the role that basement highs such as the Utsira High, played in the overall development of the rift system is subject to discussion. Previous work on the Permo-Triassic successions of the area has focussed either on large-scale models or on small-scale high-resolution analysis and lack a regional scale tectonostratigraphic framework.
The objective of this study is to bridge the gap between structural and sedimentological analysis in such a fragmented setting. By using seismic and magnetic data along with wireline, core and new biostratigraphic data from selected wells, a chronostratigraphic approach was applied. Facies associations (fluvial channel, splay and floodplain) are identified and mapped within newly defined intra-Triassic packages and their lateral variation is placed within an active rifting context. New paleogeographic maps are here presented providing new insights into the tectono-stratigraphic evolution of the area throughout the Triassic. Outcomes from this study will represent a step forward in the understanding of the North Sea Rift System evolution during Triassic times, with relevant implications for reservoir development and CO2 storage.

Hyperspectral Imaging and Evaluation of Predictive Models for Total Organic Carbon Content Estimation in Bituminous Shales

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The Total Organic Carbon (TOC) content is a crucial parameter in the characterization and exploration of hydrocarbons in the petroleum industry, particularly in unconventional reservoirs such as shales and oil sands. Due to the high cost of exploration and unpredictable production rates, there is a demand in the industry for new, accurate, and budget-friendly analytical methods to determine the properties of these rocks. This study presents an innovative alternative to rapidly, efficiently, and inexpensively estimate hydrocarbon abundance in rock samples with the assistance of Artificial Intelligence. The proposed alternative combines geochemical analyses of TOC with hyperspectral analyses of drilling cores and samples from unconventional reservoir rocks. The method leverages the processing power of machine learning algorithms and the vast amount of spectral response data acquired in the short-wave infrared range (1000-2500 nm) of the electromagnetic spectrum. As a novel alternative, the developed methods primarily focus on testing different algorithms, hyperspectral data preprocessing methods, training architectures, and combinations of machine learning algorithm hyperparameters. Algorithm training and testing were conducted on geochemical and hyperspectral data from a drilling core intercepting oil shale laminae from the Horn River Group, Canada, aiming to generate a predictive image of TOC in the core. The results demonstrate that the predictive model developed on the dataset outperformed the precision and accuracy achieved by other studies using traditional geochemical estimation methods from hyperspectral responses. The findings of this research confirm the efficiency of using machine learning algorithms over traditional methods for creating geochemical predictive models from hyperspectral imaging data. The developed method can be widely employed to generate predictive images of TOC, achieving a mean squared error below 1, from hyperspectral responses of rocks in the same lithological context.

Enrichment of organic carbon in deep-water sand-prone slope facies: A study from the Aínsa Basin

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Dilute flows transporting fine-grained sediments such as silt or clay in suspension are thought to be the principal carriers of organic carbon. However, observations from submarine fan datasets show that plant debris can be accumulated in a plethora of sandy facies, which suggests that organic carbon buried in such environments could make a significant contribution to the total amount of sequestered organic carbon in submarine fans.

Here, we present insights on the distribution of organic carbon in relation to grain size and facies from slope deposits of the Arro System, Aínsa Basin (Spain).

Evaluation of TOC content by C/S analysis from 82 samples (collected from canyon fill deposits, channel-overbank deposits, mass transport deposits, and intraslope lobe deposits) show that there are distinct partitioning patterns of organic carbon between different deposits observed depending on facies, grain size and depositional sub-environment. Main outcomes of this study are: 1) Fine-grained sandstones are generally enriched in organic carbon (average of 0.78 wt% TOC) even compared to silt-prone deposits (average of 0.45 wt% TOC); 2) hemipelagic background deposits are not the main depocenter of organic carbon, which is preferentially stored within the turbidite system; and 3) deposits exhibiting sinusoidal stratification show the highest organic carbon content independent from grain size. Sinusoidal stratification indicates high rates of aggradation by quasi-steady supercritical flows, allowing for the preservation of organic material in stable antidune deposits.

Our study shows the partitioning of organic carbon across slope deposits is dominated by different depositional processes. These need to be considered to understand the true variability of carbon sequestration within deep-marine sediments.

The understanding of this variability is important as wrong assumptions about carbon content can be made from studies that ignore spatial and compositional differences and potentially lead to false interpretations of climatic/tectonic changes and estimations on carbon budgets.

Sedimentary evolution and climatic dynamics of Lanzarote (SP): a comprehensive sedimentological inquiry from the Last Interglacial to the Holocene

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This study explores the complex sedimentary processes that have shaped the landscape of Lanzarote, the easternmost volcanic island in the Canary Archipelago. The island's subtropical hot desert climate, marked by minimal precipitation (100–250 mm/a), significantly influences sedimentary dynamics. Colluvial fans, evolving into debris-flow and water-flow dominated alluvial fan systems resulting from the erosion of the Famara Miocene volcano, dynamically interact with wind-blown sandy sediments generated in the El Jable plain.

The stratigraphic sequence of the sedimentary basin is unveiled through facies analysis and facies correlation. Luminescence and radiocarbon dating techniques contribute to chronological perspective, offering insights of the temporal dynamics of these geological processes.

The basin unfolds its sedimentary chronicle from the Last Interglacial to the Holocene, reflecting climatic fluctuations over the past 130,000 years. Alluvial fan deposits, categorized into proximal, intermediate, and distal zones, reveal a chronological sequence based on their proximity to the source. These deposits were formed during specific periods, including Marine Isotope Stages (MIS) 5d, MIS 3, and the Holocene. The drier climate prevailing during MIS 5e, 5b, and MIS 4 facilitated the expansion of dune systems, progressing from the El Jable plain towards the Famara cliff.

This sedimentological framework elevates our comprehension of Lanzarote's geological evolution and its adaptability to climatic variations. It serves as a significant contribution to paleoenvironmental reconstruction, shedding light on the island's response to changing climatic conditions over extended geological time scales.

Quaternary earthquake-triggered turbidites and homogenites from the Lesser Antilles

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The Lesser Antilles is an active margin in the Atlantic Ocean where two major (M ≥ 8) historical earthquakes were reported during the last two centuries on January 11, 1839 and February 8, 1843. These two major seismic events resulted into the destruction of Pointe-à-Pitre and Fort-de-France in the islands of Guadeloupe and Martinique, respectively. More recently, in 2007, a M = 7.4 earthquake occurred between the islands of Dominica and Guadeloupe and promoted significant damage on several buildings and roads. A better understanding of the seismic hazard induced by earthquakes along the subduction zone motivated a submarine paleoseismological study in the Lesser Antilles forearc basins.

The high-resolution analysis of the physical and magnetic properties of three long sedimentary cores (up to 29 m in length) sampled on board the R/V Pourquoi Pas? in 2016 during the CASEIS Expedition (https://doi.org/10.17600/16001800) revealed several meter-thick rapidly deposited layers. These deposits are composed of a basal turbidite topped by a homogenite, termed homogenite-turbidite complexes, and are most likely the signature of large magnitude earthquakes. Age models for each of the cores studied were derived from radiocarbon dating, planktonic foraminiferal biostratigraphy and relative variations in the intensity of Earth's magnetic field. These sedimentary records will be used here to establish the chronology of large magnitude earthquakes during the last 80 ka and to determine the sedimentary processes associated with homogenite-turbidite complexes in deep marine basins.

Temporal variability of fluvial sediment composition: An annual time series from four rivers in SW Germany

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Rivers are a crucial part of sediment systems as they transport detritus from source to sink. Sedimentary system analysis aims to unravel the processes that control the generation, transport, and deposition of sediment. However, any method that relies on sediment samples is prone to errors introduced during sampling, sample preparation, and analysis. The quantification of these errors should be an integral part of sedimentary system analysis. The sampling of sediment is subject to many sources of uncertainty, e.g., time and location of sampling, and the number of samples collected. It is commonly assumed that a sample taken at one time and location provides a somewhat averaged compositional signal and any spatial or temporal variability of this signal is often neglected. We investigate how the composition of bed load sand changes over an observation period of one year in four river basins with differing bedrock geology in southwestern Germany. Up to 12 bulk sediment samples were taken at the same locations and analyzed for their granulometry and geochemistry. The results indicate that (a) different grain sizes yield different compositions due to source rock composition and hydraulic sorting effects, (b) bulk sediment composition changes temporally due to changing grain-size distribution, and (c) compared to the bulk sample, the composition of narrow grain sizes is temporally more stable, but still has an average variability of 15%. Because heavy mineral-bound elements have the highest variability, we relate a major component of compositional variability to hydraulic sorting effects. Mixing modeling demonstrates that fluvial sand faithfully reflects its catchment geology and that sediment sources do not change substantially during the observation period, even during a flooding event. We conclude (a) that the causes for compositional variability may be disentangled using time series data and (b) that narrow grain sizes yield representative source rock contributions.

Carbonate platform facies identification by means of integrated LWD measurements (UAE)

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Extra Deep Azimuthal Resistivity (EDAR) logging while drilling tools are used in the oil industry to log the resistivity properties of the formation around the wellbore. By means of a wide sensors spacing, and selecting specific electromagnetic frequencies, the depth of detection of EDAR can reach up to 30 m around the wellbore, depending on the resistivity of the formation being drilled and surrounding formations. The measurements provided by EDAR tools are then processed by data inversion software, generating the resistivity model that best fits the measured signals..

Resistivity inversion of EDAR measurements was deployed during the drilling of a high-angle well into a carbonate platform formation. The wellbore initially navigated close to the top of the carbonate platform and then inclination was dropped, cutting through the section. Due to strong resistivity contrast between the carbonates and the overlying shales, inversions confidently resolved the top of the carbonate platform along the section interval drilled close to the carbonate platform roof, mapping a sub-horizontal, undulated surface. After changing hole inclination, the lower resistivity contrast across the body of the carbonate platform affected the resolution of the inversions and no surface could be mapped with continuity. However, the trend of the resistivity inversions showed a change of orientation of the formation dip. The general shape of the surfaces mapped by the resistivity inversions model fitted the geometry of a flat-topped carbonate platform with a progradational clinostratified slope, in agreement with the understanding of the depositional setting of the formation based on seismic sections.

Although the internal structures of the carbonate buildup were resolved with less confidence by inversion modelling, still some finer features were mapped. This allowed the identification of a patch reef, back-margin beds onlapping an aggradational carbonate platform margin and the clinoforms of the progradational carbonate platform slope.

Pre-Eocene Arabia-Eurasia collision: New constraints from the Zagros foreland basin, Iran

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The timing of continental collision between Arabia and Eurasia is a highly controversial geological issue, on which new cogent constraints are here provided from the Upper Cretaceous to Eocene stratigraphic succession of the Amiran Basin (Zagros Mountains, Iran). Upper Cretaceous carbonate ramps grown along the Arabian northern margin are overlain by the siliciclastic Amiran and Kashkan formations, dated biostratigraphically as 64-60 Ma (Paleocene) and 56-52 Ma (earliest Eocene), respectively. Abundant ophioliticlastic supply, detrital Cr-spinel geochemistry, and detrital zircons with positive εHf(t) values dated as 110-80 Ma, 180-160 Ma, and 260-200 Ma indicate that the Amiran Formation was mostly derived from the obducted Kermanshah ophiolite and Sanandaj-Sirjan Zone. Besides sharing similar sandstone composition and detrital zircon-age spectra, the overlying Kashkan Formation contains recycled sedimentary detritus and one new age component of detrital zircons with negative εHf(t) values dated as 250-200 Ma, suggesting supply from additional sources located in Central Iran. The Amiran Formation thus indicates that the Kermanshah ophiolite, obducted in the Late Cretaceous, was subaerially exposed to erosion in the Paleocene. The Kashkan Formation testifies to the establishment of a new fluvial system, sourced in Central Iran and flowing across the Zargos suture zone. This implies that continental collision between Arabia and Eurasia took place before the beginning of the Eocene (i.e., before ~56 Ma) in the Lorestan region (Iran).

The Application of Dual Clumped Isotopes to the Identification of Microbial Processes Involved in Carbonate Precipitation

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Microbes are known to play important roles in the formation of many carbonate minerals, yet clear identification of their influence using either geochemical or physical evidence is often equivocal. In this presentation we provide evidence, using the dual clumped isotope proxy (Δ_{47} and Δ_{48}), of the influence of microbes in the formation of dolomite, calcite and aragonite in situations previously believed to have been primarily inorganically controlled or in which the formation mechanism was uncertain. The dolomite examples have been derived from occurrences in the Bahamas that are known to have formed either from normal or slightly modified seawater and others which have clearly been influenced by microbial sulphate reduction (MSR). Dolomites formed by open marine processes have Δ_{47} and Δ_{48} values close to equilibrium while those formed in association with MSR have much lower than expected Δ_{48} values and only slightly lower Δ_{47} values. The examples of the influence of MSR on the formation of calcitic cements have been taken from meteorically altered Pleistocene reefs from the Dominican Republic. Cements forming close to the water table, a region previously identified as showing MSR, have lower than expected Δ_{48} values, while cements formed in association with physical processes such as CO_2 degassing, have elevated Δ_{48} and lower than expected Δ_{47} values. Finally, we present data on the formation of non-skeletal carbonate from the Bahamas that suggest while the majority of the skeletal forming organisms are forming in equilibrium, the non-skeletal components form in disequilibrium. These data show an innovative application of the clumped isotope proxy.

Which sediments are most prone for liquefaction? Textural characteristics of liquefied sediments based on field studies

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Some geological processes such as earthquakes, volcanic eruptions and salt tectonics can mobilize water-saturated sediment. During this phenomenon intergranular contacts are lost. The well-known liquefaction-prone sediments are fine-grained sediments, i.e. sands and silts, in which this phenomenon can be recorded as soft-sediment deformation structures (SSDS). The aims of the research are (1) to describe the grain size of liquefied sediment from eight study sites, (2) to demonstrate statistically significant differences and dependencies in the textural properties of liquefied sediments, and (3) to mathematically determine the properties of sediment susceptible to liquefaction.

The grain size of 144 sediment samples collected from eight study sites, where liquefaction-induced SSDS were identified, are analyzed. The most important results are related to the determination of critical values of individual sediment fractions, as well as basic statistical parameters of the liquefied sediments divided into four groups. We also conclude that not only the share of individual sediment fractions, but also relationships between them have a significant impact on the initiation of the liquefaction phenomenon and type of the following sediment deformation. In none of the analyzed sediments did the content of the clay fraction (<2 µm) exceed 14%. This value, compared to the results of previous research, seems to be the maximum clay content in sediments susceptible to liquefaction. A high clay content is also associated with a high silt content. Mobilization of the silt fraction is the driving force initiating the further deformation process.

Based on the collected data, the content of individual fractions was calculated and then interpolated for broader range of sediments. Thus, the results can be used as a tool in estimation of the potential liquefaction susceptibility and type of deformation for loose clastic sediments.

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Sediment transport and beach evolution in areas with complex shoreface bathymetry

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The bathymetric configuration of the shoreface is partly controlled by the antecedent topography of the basement. In high-energy sandy regions, this zone is very dynamic and often includes a mobile shore-parallel sandbar. However, numerous locations around the world are characterized by anomalous shore-oblique ridge and trough systems that are strikingly stable, even after storm events. In many cases, these features are linked to coarse paleo-river deposits that underly the modern sediment. The persistence of these features induces continuous alterations to regional hydrodynamics that often create hotspots of beach erosion. In this study, a combination of remote sensing data and numerical modeling results explore the formation of complex bathymetric environments and their influence on modern day sediment transport processes. A site in the Outer Banks of North Carolina in the United States was analyzed during several storm events that occurred in 2017. Results indicate that, across a variety of incident wave conditions, the complex bathymetry alters wave breaking patterns and produces re-emergent rip currents that flow down the bathymetric axis. These currents remove sediment from the beach face and contribute to zones of accelerated erosion. Hydro-morphodynamic feedbacks also prevent the deposition of sand in these zones, thus contributing to the stabilization of these features. Over time, these features may locally threaten the integrity of the barrier island and cause this region to be at higher risk of breaching and overwash. The potential role that the underlying paleo-river deposit plays in the initial formation and continual maintenance of the present-day bathymetric configuration will also be explored via idealized numerical simulations.

Fibrous clay origin in lagoon environments: new insights from a Lutetian-Bartonian (Eocene) event in the Paris Basin

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Models for palygorskite formation have been proposed for carbonate lacustrine or terrestrial environments. Precise mechanisms and forcing parameters (e.g., climate or palaeogeography) that may trigger such fibrous clay formation, have to be better understood in ancient sedimentary environments. In the Paris Basin, fibrous clay minerals associated with microcrystalline dolomite have long been inferred in the late Lutetian, yet the processes and factors controlling their formation remain unclear.

This study is based on four sections forming a NE-SW transect, which record an equivalent fibrous clay episode within the 'Marnes et Caillasses' Fm. (late Lutetian – early Bartonian transition), often associated with microcrystalline dolomite. Due to its stratigraphic position, this episode most likely encompasses the Late Lutetian Thermal Maximum (LLTM), previously recognized in the deep ocean and associated with extremely high insolation values favouring the development of arid conditions. Using a new dataset based on XRD, petrography (cathodoluminescence, epifluorescence) and electron microscopy (TEM and SEM imaging), processes for fibrous clays and dolomite co-occurrence are proposed. Elemental geochemistry based on Laser Induced Breakdown Spectroscopy (LIBS) and XRF profiles help to refine the evolution of geochemical conditions in the environment.

Our results provide evidence for a transformation of Mg-rich smectite into neoformed palygorskite and sepiolite under arid environmental conditions. The microcrystalline dolomite is likely induced by microbial processes and its subsequent partial dissolution could have release additional magnesium for palygorskite formation. LIBS analyses confirm an increase in alkaline ions such as lithium concomitant with this fibrous clay episode. Arid climate during the LLTM, combined with confinement of the Paris Basin caused by regional uplift, are likely the key forcing parameters that enhanced fibrous clay formation.

ANISOTROPY OF MAGNETIC SUSCEPTIBILITY (AMS) AS A TOOL IN THE IDENTIFICATION OF FINE-GRAINED, CALCAREOUS, CONTOURITE DEPOSITS WITHIN THE GEOLOGICAL RECORD: THE VACA MUERTA FORMATION (UPPER JURASSIC-LOWER CRETACEOUS), NEUQUÉN BASIN, ARGENTINA

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Determination of paleocurrents in fine-grained, distal-marine facies is challenging due to the limited presence of traction and/or erosive structures. The AMS method is an effective technique to address this issue.

In this study, a paleocurrent analysis using AMS is presented for the Vaca Muerta Formation, the most important unconventional reservoir in Argentina and a world-class source rock. This unit represent a mixed, carbonate-siliciclastic, low-angle prograding, clinoform system. Sampling was conducted on intraclastic and peloidal rich, outer ramp carbonate facies composed of packstones/grainstones with horizontal lamination, ripple cross-lamination and cut-and-fill structures. Abundant bioturbation is also observed. Recent studies interpreted these deposits as contourites, although paleocurrents were not provided.

Primary magnetic fabrics were identified, showing clustered kmax and kint axes within the depositional plane, and subvertical kmin axes with imbrications of up to 20º. This fabric type results from the action of bottom currents, where the flow direction is parallel to the clustering of kmax or kint, depending on the flow regime. The obtained fabrics are attributed to the processes of low regime flat-bed migration and current ripple migration. The estimated paleocurrents are predominantly in the NE-SW direction, perpendicular to the SE-NW direction of progradation of the clinoform system. These results support the existence of contour currents during the deposition of the Vaca Muerta Formation. Furthermore, the observed bioturbation suggests that contour currents acted as a mechanism oxygenating the seafloor, promoting benthic colonization of the substrate, reducing the organic matter content, and affecting the petrophysical quality of the deposit. This contribution serves as an example where the AMS technique is a useful, fast, non-destructive method complementary to sedimentological, petrographic, and ichnological analyses for identifying contourite deposits in subsurface. The detection of these lithosomes is important because they serve as seal rocks in the petroleum system, and they negatively impact hydraulic fracturing processes.

Along-axis synchronous initiation of Shanxi Rift by late Miocene: implications for the linkage between Pacific subduction and intracontinental rifting

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Shanxi Rift, an active intracontinental rift, located in the central zone between the effect of India-Eurasia collision and western Pacific subduction, is an important lithospheric-scale structure for understanding the role of plate boundary processes in intracontinental rifting. However, the initiation mode of Shanxi Rift has not been conclusively identified due to limited evidences for the inception and evolution of rifting, especially in the central segment of the rift. Here, based on a continuous, 1533 m - long core succession recovered from the Taiyuan Basin of the central Shanxi Rift, we conducted an integrated study of lithostratigraphy and magenetostratigraphy of the syn-rift deposits. Facies analysis shows that the syn-rift deposits are lacustrine - deltaic - fluvial origin, and the basin-filling sequence can be divided into five sedimentary units. The magnetostratigraphy of the sequence is well established, with an extrapolated basal age of ca. 7.4 Ma, indicating the onset timing of basin formation. Depending on the sedimentary evolution, basin analysis reveals that the structural evolution of Taiyuan Basin experienced rift initiation, rift climax, and post rift stages, which represent the typical extension process in rift basins that characterized by a sequence of slower-faster-slower subsidence rate. The newly obtained onset timing of central rift zone, coeval with the northern and southern rift zones, enable us to reach a definitive conclusion regarding the rifting mode of Shanxi Rift that synchronously activated since the late Miocene (ca. 9-7 Ma). The synchronous activation of Shanxi Rift is spatiotemporally consistent with the processes induced by Pacific subduction, probably indicating the dynamical links between rifting and subduction. Furthermore, a broad-scale spatiotemporal coherence in eastern Asian deformations, including Shanxi Rift and Baikal rift, imply a potential role of Pacific subduction in intracontinental rifting.

Depositional architecture and reservoir characterization of clastic, shallow geothermal resources in the Netherlands – From a data driven to process based approach in national geothermal resource assessment

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Geothermal development in sedimentary basins in the Netherlands can benefit considerably from subsurface data acquired by hydrocarbon exploration. A decade ago, this data was re-used to create nationwide geothermal potential maps. ThermoGIS includes key parameters such as aquifer depth, thickness, flow properties and temperature. A techno-economic tool allows identifying prospective regions. As the medium deep subsurface (200-1500m depth) was never targeted for petroleum nor groundwater applications, it is relatively unknown. To decrease uncertainties within this depth range, mostly comprising Cenozoic shallow to neritic marine, estuarine and fluvial clastic sediments, the Geological Survey and its partners focus on understanding the depositional history, facies distribution, flow properties and diagenetic imprints of sedimentary units of interest for shallow geothermal energy production and heat storage.

A first example is the Brussels Sand Member (BSM, Middle Eocene). It occurs at depths down to 1300m (temperatures <60°C) and consists of a 100-240 m thick, coarsening up sequence of marine shelf sands that grade northwards into marls. New interpretations of seismic surveys and well logs allowed to consistently map the extent, regional trends and three-fold subdivision of the BSM. Despite being mostly unconsolidated, thin calcite beds occur, especially near the top and in the shallower margin of the depocenter, where the most promising reservoir levels are located.

The Breda Formation (Late Oligocene – Early Pliocene) is a second interesting unit. It mostly consists of shallow marine and coastal sands. In the Miocene Roer-Valley Graben it reaches a large thickness and depth, but lithology and depositional architecture are uncertain.

A conventional data-driven mapping to understand the relationship between reservoir properties, diagenetic trends and sedimentary architecture meets its limitations. A shift to an integrated approach including forward stratigraphic and diagenetic modelling is investigated to include more sedimentary process-based predictions of lithological variation that influences flow and thermal sediment properties.

Phosphatic ironstone of the Rapid Creek Formation, Northwest Territories, Canada: Cretaceous Oceanic Anoxic Events and critical mineral deposits

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The Aptian-Albian Rapid Creek Formation is a phosphatic ironstone located in the Richardson Mountains, northern Yukon and Northwest Territories. The Rapid Creek Formation is a low-grade Fe deposit containing ca. 27 billion tonnes of ironstone enriched in P and Mn (33% $Fe2O3$, 14% $P2O5$, 5% MnO). Deposition occurred in the Blow Trough of the Sevier foreland, which was a north-south oriented structural depression ca. 50 km wide that connected the Western interior Seaway to the Nascent Arctic Ocean.

At the type locality near Rapid Creek, Yukon, the Rapid Creek Formation is ca. 1000-m-thick and composed of nine stacked cycles that coarsen from a basal mudstone to a P-rich, granular ironstone. Our focus is on the sedimentology and sequence stratigraphy east of the type section, along Little Fish Creek, Northwest Territories, where its thickness thins to ca. 200 m. Here, three stacked, coarsening upward cycles are interpreted as parasequences, each recording shallowing through storm wave base. Parasequences are defined by flooding surfaces overlain by laminated, organic-rich mudstone that grades upwards into hummocky cross-stratified granular ironstone. The thickness of these granular ironstone tops increases in each parasequence, suggesting increasing progradation during early highstand conditions.

Parasequences are interpreted to record the precipitation and accumulation of upwelling-related ironstone that was reworked by storms. Lithofacies associations suggest upwelling tapped nutrient-rich, ferruginous bottom water, which also stimulated high surface ocean productivities. The expanding Arctic Ocean with restricted circulation and vigorous ridge activity supplied anoxic seawater enriched in hydrothermal Fe and critical elements (Mn and REEs) to the Blow trough. Such an interpretation implies that at least some Cretaceous Oceanic Anoxic Events like the Aptian-Albian OAE 1b were regional rather than global events. Reinterpretation of ironstones like the Rapid Creek Formation also provides a foundation for developing new exploration models tuned for discovering critical mineral deposits.

Study on sedimentary characteristics, sedimentary microfacies and genetic mechanism of lacustrine mixed sedimentary rocks

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The continental lake basin has a small distribution range and shallow water body. Compared with the marine environment, the lake sedimentary environment is more susceptible to external factors such as terrestrial debris input, climate change, and tectonic movement, which is more conducive to the development of mixed sedimentary rocks composed of carbonate rocks and terrestrial debris.

A large number of lacustrine mixed sedimentary rocks are developed in the upper 4th Member of Shahejie Formation of Palaeogene in Bohai Bay Basin, China. In this study, based on drilling core and geochemical test data, using terrigenous clastic rock-biogenetic carbonate rock-chemical carbonate rock three end member division scheme, 12 rock types were divided in the study area, and on the core and thin section scale, different types of rock composition and sedimentary structure characteristics were analyzed. Combined with the corresponding characteristics of logging and seismic, seven types of sedimentary microfacies are summarized. On this basis, according to the research idea of ' point-line-surface-body ', the spatial distribution characteristics of different microfacies are identification: the slope on the west side is large, the injection of terrigenous debris is weak, and the mixed deposition is less developed; the source supply in the middle is strong, and the mixed deposition is mainly distributed in the periphery of the fan. The east slope is gentle, the lake wave has the strongest influence, and the mixed deposition is widely developed.

Finally, it is speculated that the basin structure and paleogeomorphology, lake level change, parent rock composition, water salinity change, and other conditions jointly control the formation and evolution of the lacustrine mixed sedimentary system, and a comprehensive genetic model of ' provenance-basin-salinity ' controlling the development of lacustrine mixed sediments is proposed.

The Vital Role that Geoscience and Sedimentology will play in the Energy Transition

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Over the past Century, the global population has increased fourfold from just 2 Billion in 1928 to over 8.1 Billion today. It is projected to rise yet further to exceed 11 Billion by 2100. Growth of his magnitude places enormous pressure on Earth Systems and its resources as people seek to improve their quality of life, but with negative consequences on biodiversity, the environment and climate. Over the same period, the levels of atmospheric carbon dioxide have risen from 300ppm to over 420ppm and carbon dioxide emissions have gone from 4 to 35 Gigatons per year, with all the consequences for global warming and sea level rise that has. In this context, it is an inconvenient reality that fossil fuels currently account for over 80% of primary energy consumption and even countries that have weaned themselves off coal, still rely heavily on oil and gas to power industry, keep the lights on, heat homes and to meet their transportation needs (e.g. 75% dependency in the UK). Given the stark figures, the starting point on our road to decarbonise society and meet net zero emissions targets is an extremely challenged one, and a misstep along the way could impose blackouts, power outages, impose fuel poverty and job losses.
In light of recent global events, there has been an increasing appreciation and focus on trying balance the energy trilemma that ensures security of supply, affordability, and environmental sustainability & climate compatibility to ensure that there is a smooth transition rather than a cliff edge, with a highly variable degree of success. While some are intent on shutting down industrial clusters, doing so will come at a cost to jobs, communities, national economics (GDP), energy security and, given the demand for the products is unlikely to diminish, the (higher) carbon footprint will simply be exported. We are in danger of not learning the lessons of past mistakes which afflicted coal mining, ship-building, and the steel-making sectors to name but a few, meaning a “fair and just transition” will not be achieved. There is also an urgent imperative to gain a social license to operate from affected communities as places get rewired for the transition (e.g. offshore wind connections to the grid replace those from the old industrial heartlands).
Geoscience and sedimentology (in particular) have a huge role to play as we wrestle with the massive challenge to transition our energy systems and seek viable solutions to enable the pivot from fossil fuels to renewable sources. There is a need to have forensic data-led, evidence-based research undertaken to characterise the subsurface, seabed, and metocean conditions exist that enable industry to decarbonise and emissions targets to be met. Integration of core descriptions with wireline log analysis, seismic data and field analogues will help determine where the best sites are for carbon dioxide, hydrogen, and nuclear waste storage, (low- and high-enthalpy) geothermal energy sources, wind farms and placer deposits containing critical minerals. Despite the evident need for the expertise to communicate with communities and technically inform policy and decision-making, the career pathway is proving to be less attractive and there are serious recruitment challenges to be addressed. It is imperative that we articulate the message that our subject and its practitioners are crucial if we are going to meet the challenges embodied in the energy trilemma. As society seeks the solutions to save the planet yet continue to meet the energy needs of an increasing world population and geoscientists and sedimentology will be at the forefront of that.

The Thar Desert as a control of Sediment Flux from the Indus River to the Arabian Sea

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Deserts serve as potential sediment buffering regions in extensive drainage systems, potentially significantly influencing the composition and characteristics of sediment transported to the ocean. This study focuses on evaluating the Thar Desert's potential impact on regulating sediment discharge from the Indus River to the Arabian Sea. Key questions addressed include whether sediment supply from the river or the intensity of the summer monsoon controls expansion of the desert. Utilizing a comprehensive suite of bulk-sediment geochemical data and radiogenic isotopes, alongside with single-grain rutile trace-element geochemistry, we characterize sediment properties across different regions of the Thar Desert. Through a comparative analysis of existing data from the Indus River and associated tributaries, we identify the sources and timing of sediment contributions from various segments of the Indus drainage system. Our findings suggest that the recycling of sediment from temporary storage in floodplains may play a significant role in explaining the observed geochemical differences between the northern parts of the desert and the Indus River. The southern desert is more directly supplied from the delta, especially in the Early Holocene. This study integrates information from high-resolution marine sediment sequences and enhances our understanding of the processes governing the growth and migration of the Thar Desert within the southwestern monsoon region, of the erosion history of the Himalaya, and of the role of deserts in source-to-sink transport processes.
Key words: Thar Desert, Indus River, Arabian Sea, Sediment Flux, Monsoon, NW Himalaya

Nummulitic Limestones of the Alpine foreland basin of south-east France: paleotopographic and structural controls on transgressive carbonate facies and distribution within the Castellane arc

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Transgressive marine carbonates commonly represent the initial infill of flexural foreland basins. In this context, parameters controlling carbonate distribution and facies can be both global and local. Global parameters essentially relate to flexural subsidence of the lithosphere, orogenic front advance and eustasy, while local factors include inherited structure and topography as well as synsedimentary deformation.
Within the Alpine foreland basin of southeast France, the Eocene-Oligocene transgressive succession known as the Nummulitic Trilogy is initiated by the Nummulitic Limestone Formation (Fm). While global controls on Alpine foreland basin evolution have been well studied, less is known about local controls on basin infill. We investigate the contribution of local controlling parameters related to both the Pyrenean and Alpine orogenies to the foreland basin succession in the Castellane arc (SE France).
New sedimentological, stratigraphic and structural data on the Nummulitic Limestone are used to constrain their distribution, facies and stratigraphic geometries. Moreover, the study of the large benthic foraminifera content (Nummulites) provides constraints on basin hydrodynamics, luminosity and terrigenous input. The local presence of continental to shallow marine facies below the Nummulitic Limestone Fm, as well as the variable detrital fraction and faunal diversity around the Castellane arc are integrated into paleogeographic maps for the early transgressive foreland basin of SE France. Maps are anchored in time thanks to dating using both strontium isotopy and nannofossil recognition. The angular unconformity at the base of the foreland basin succession and the changing age of the substratum in the studied sectors are used to construct a Nummulitic subcrop map on which pre-alpine structures are identified, mainly related to the Pyrenean orogeny. Finally, thickness variations of the Nummulitic Limestone across E-W synclines of the Castellane arc suggests a syn-sedimentary north-south Pyrenean shortening still active during the initiation of the Alpine foreland basin sedimentation.

Finding tidal signatures in river-flood bar deposits in a micro-tidal mixed-energy deltaic setting (Po River, Italy)

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Recent advances in understanding the morpho-sedimentary dynamics of mixed-energy coastal systems highlight that the interplay of processes (i.e., tides, waves, river) can be cryptic to decipher in ancient sedimentary successions, where common evidence for tidal sedimentary processes can lead to 'overinterpretation' of tidal energy. Modern river-and-delta systems offer direct measurements of whether tidal signatures may be present in deltas without clear evidence of tidal control on their overall morphology. To this end, we evaluated the relative importance of tidal and river processes in deposition occurring in the backwater and fluvial marine transition zone (180 km long), of the Po River (Italy). The Po River debouches in the micro-tidal Northern Adriatic Sea and is considered a river-wave, mixed-energy, fluvio-deltaic system based on the absence of macro-morphometric features considered diagnostic of tidal control on morpho-sedimentary processes (e.g., channel funneling). Sediment cores from side-attached bars in the distalmost ~30 river kilometers show heterolithic facies, sparse double mud drapes, sand-mud couplets and sporadic bidirectional current ripples. Trenches reveal meter-scale cycles of alternating intervals with well-defined and poorly-defined laminae in the distal reaches of the delta. In combination with historical water-level data, these cycles are interpreted to result from semi-diurnal tidal modulation during river floods. This contrasts the lack of cyclic patterns in trenches in proximal reaches of the study area, and the rare occurrence of similar cycles in the medial reaches. This study highlights that preservation of tidal rhythmites within intertidal bar deposits is possible, despite the microtidal setting and dominance of river energy at times of deposition. Further, despite no discernible control of tidal forcing on the Po River delta morphodynamics, tide-related structures are widespread. Hence, we support the idea that care should be taken in interpreting dominance of processes based on the occurrence of sedimentary structure, and vice versa.

Sediment supply controls on Early Eocene delta sequences (South Pyrenean Foreland Basin; Spain)

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Sediment supply variations are often overlooked when interpreting depositional sequences, which tend to emphasize changes in accommodation. Here, we focus on a temporally well-constrained shallow-marine succession in the South Pyrenean Foreland Basin to test the control of sediment supply on the development of deltaic sequences during the Early Eocene. We analyzed the paleoenvironmental record (sedimentary facies and $\delta^{13}C_{org}$ values) of the Morillo Limestone and the Castigaleu Formation from 52.2 to 50.3 Ma. During this period, a series of hyperthermal events occurred, globally recorded as negative carbon isotopic excursions (CIEs). The major progradation of the deltaic system is marked by the abrupt appearance of thick delta-front sandstones and coincides with the first recorded negative CIE. Subsequent phases of progradation/aggradation align with subsequent negative CIEs. Conversely, positive CIEs correspond to finer-grained, more distal prodelta and offshore deposits. We therefore suggest that during deposition of this Early Eocene shallow-marine succession, the primary trigger behind sequence generation was the climate-induced variation in sediment supply, specifically the hyperthermal events, rather than changes in accommodation. This linkage underscores the complex interactions between climate dynamics and sedimentary responses, shaping the stratigraphic architecture of shallow-marine settings.

Stasis in Cambrian quartzites: True substrates, trace fossils, and the time-stratigraphic fidelity of sandstones deposited in epeiric seas

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In many Palaeozoic basins, the oldest strata consist of shallow-marine quartzites, deposited in epeiric seas during the Cambrian Period. The widespread occurrence of this archetypal facies is coincident with the rise of animal life (i.e., the Cambrian Explosion), giving such quartzites potential palaeobiological significance. However, the epeiric quartzite facies is the product of various unique conditions of marine sedimentation, complicating their interpretation: for example, the vastness of the epeiric seas in which they were deposited, or the fact that their formation preceded the mid-Palaeozoic evolution of land plants, which changed the dynamics of fluvial systems and the sediment flux to the oceans. Case studies from Laurentia, Baltica, and Avalonia provide an opportunity to reconstruct the interplay between erosion, deposition, and stasis in such anactualistic settings. The abundance of thick, texturally mature, cross-stratified quartzites have informed the traditional view that this facies represents thorough reworking in environments dominated by erosion and bed amalgamation. However, bedding plane characterization based on surficial trace fossils and sedimentary structures newly shows that, besides erosive contacts, Cambrian quartzites commonly host bedding planes that represent intervals of sedimentary stasis and have preserved the ancient sediment surface without subsequent erosion (i.e., ‘true substrates’). The brevity of recorded stasis means that these bedding planes preserve instantaneous snapshots of the seafloor, and that the spatial distribution of surficial trace fossils can accurately represent their abundance in the original depositional environment. Such bedding planes differ from those found in more offshore facies, which record longer intervals of stasis and more time-averaged ichnological assemblages. Different epeiric facies may thus host signatures of the Cambrian Explosion, but the interpretation of such datasets should be contextualized by the duration of stasis that is archived in each sub-environment.

Record of recent activity in the Gollum Channel System, offshore Ireland.

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The Gollum Channel System is a land-detached large-scale canyon-channel system situated offshore southwest Ireland on the Northeast Atlantic margin. The system is considered to have been inactive since the Last Glacial Maximum (LGM), but newly acquired geophysical seafloor and shallow subsurface data do suggest recent activity. Here, geophysical, geochemical and sedimentological data from six sediment cores are presented to build a post-LGM record of channel activity and test the inactivity hypothesis. Furthermore, the Gollum Channel System provides the only pathway for downslope transport of material moving westwards from the Celtic Sea Shelf. Therefore, this record may also provide information on the advance and retreat activity of the last British-Irish Ice Sheet (BIIS) at its southwestern border and thus fit into the ongoing broader investigation of BIIS activity. Two of the cores are situated on the floor of one of the channels while the other four form a transect from the channel shoulder to the more distal interfluve. The channel floor cores show layered intervals characterized by a coarser lithology and/or different sediment composition compared to the background sediments. These milli- to centimetric layers are interpreted as pre-Holocene deposits from downslope gravity flows, suggesting channel activity during the deglaciation after the LGM, when the BIIS was retreating from the shelf edge.

Diagenetic controls on pore space development in a Middle to Late Jurassic spiculitic cherts; example from Austrian Mollase basin

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Siliceous sediments including sponge-spicule-rich sediments are known for their chemical instability due to the presence of amorphous silica. In the course of progressive burial, the amorphous silica undergoes transformation to more stable phases like chalcedony or quartz. These diagenetic transformations govern the development of pore space in the spiculitic cherts. The products of these diagenetic transformations are variable megascopic to microscopic chert fabrics, which control the distribution of pore space.

The studied subsurface cores from the Höflein Formation in the Austrian Molasse basin comprise spiculitic chert, sparry dolostone with various amounts of terrigenous sand, and dolomite-cemented sandstone. The dolostone units are light greyish to greenish, partially glauconitic and sandy, containing irregularly distributed, white nodular porous or tight chert and occasionally interbedded wispy shale streaks. The Höflein Formation occurs over large areas and exhibits practically little lateral facies variation, apart from a siliciclastic-dominated unit in the middle part of the succession.

The pore space in the spiculitic cherts is of purely diagenetic origin and therefore, the pore space distribution is heterogeneous and does not follow any depositional trends. The main pore types are interconnected mouldic/intraparticle macropores, isolated mouldic macropores, matrix microporosity and microfactures. The pore space preservation is mainly controlled by the degree of silica cementation. Chert nodules show general zonation with a tightly cemented core and a less cemented rim. The spiculitic cherts were diagenetically overprinted by pervasive late diagenetic dolomitization, which resulted in pore space degradation by dolomite cement, replacement of the rock matrix and partially masking the primary sedimentary structures.

Depositional architecture of the Carboniferous fluvial deposits with accompanying deltaic and marine lithofacies in the Lublin Basin, SE Poland: selected examples from completely cored borehole sections

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The investigations were made based on geological and geophysical data from about 100 boreholes located in the Lublin Basin (SE Poland). Lithofacies analysis of the available cores allowed to distinguish several lithological varieties, i.e. limestone, marl, claystone, mudstone, sandy siltstone, sandstone, conglomeratic sandstone, sandy conglomerate, conglomerate, claystone/mudstone/sandstone Stigmaria soil, carbonaceous claystone and coal, which occur in the Carboniferous succession. Its thickness ranges from several dozen to approximately 1,660 m. Based on lithofacies, cyclicity and sequence stratigraphy analysis, a reconstruction of the depositional architecture of fluvial deposits together with the accompanying deltaic and shallow carbonate and clay shelf sediments was made. Three main types of cyclothems with various subtypes have been distinguished, i.e. fining-upward, coarsening-upward, and non-gradational. Lithofacies and their associations have been coded and characterized, formed in the fluvial environment, as well as in hyperconcentrated flows that occurred in river channels and incised valleys. Lithofacies associations characteristic of distal sand-bed braided rivers include, i.e.: high-energy, deep and distal sheetflood, but also sand-bed meandering and anastomosing rivers were identified. The Carboniferous succession is characterized by large variability, related with cyclic appearance of particular sedimentary environments, as well as the modifying influence of relative sea-level oscillations and local tectonics. The thickness relationships of deposits representing various environments within the Tournaisian and Visean indicate a delta–marine depositional regime, and within the Serpukhovian-lowermost Bashkirian – a delta regime. In this part of the section, fluvial sandstones are rare as isolated, thin lithosomes. Then, the lower Bashkirian is characterized by a high contribution of sediments formed in river channels and incised valleys, as well as in various floodplain sub-environments. The upper Bashkirian-Moscovian succession may be distinguished by a clearly fluvial sedimentation regime. Aggradation of large incised valleys deposits caused the formation of the thickest sandstone, which is also characterized by the largest lateral distribution.

Mapping and spatial analysis of sandstone intrusion geometries within the Panoche Giant Injection Complex, California, USA

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Sandstone intrusions are sourced from re-mobilised depositional units, termed Parent Units. Overpressure of these depositional units results in fluidisation of the parent units and hydrofracturing of the overlaying strata. The fluidised sand is injected along the fractures and acts as a proppant, keeping them open and hence forming sandstone intrusions. The scale, number and geometries of sand intrusions can be extremely varied, even within a single injection system. Sandstone intrusions often form highly complex and interconnected networks, which provide vertical connectivity within a deposition system.

Outcrops of sand injectites have been described for over a century, with outcrops in the UK, Greenland, France, Brazil, Chile, Antarctica, and the USA, but only recently has their importance to sedimentary systems become recognised. The Panoche Giant Injection complex (PGIC) is located in central California, on the western margin of the San Joaquin fore-arc basin and is the largest exposure of sand injectites in the world. The PGIC is hosted predominantly in the late Maastrichtian Moreno and Panoche Formations, with exposure extending along strike for over 30km and 600m of stratigraphy.

Recent advancements in photogrammetry and satellite imagery, integrated with traditional fieldwork techniques (sedimentary logging, field sketches and structural measurements) have made it possible to regionally map the intrusions within giant injection complexes. Within the PGIC 8413 intrusions can be identified and accurately mapped, with individual intrusions ranging between 0.01m and 16m thick. Digital mapping allows for analysis of the geometry and spatial variability of intrusions within the injection complex. This provides input parameters for the creation of geological concepts and modelling of sandstone intrusion facies.

The controls on large deep-time coarse-grained fan deltas in Western Junggar Basin: insights from modern source-to-sink systems using stratigraphic forward modeling

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There still exist debates about the transport regime of gravels in gentle lacustrine depressions across long distance to form large fan deltas in Western Junggar Basin. Therefore, this study compares modern source-to-sink (S2S) systems and deep-time fan deltas using stratigraphic forward modelling (SFM) to investigate the controls of coarse-grained fan deltas. Firstly this study restored the paleo depositional environment during the Upper Wuerhe. Then dozens of simulations were carried out using SFM with Dionisos for the deep-time fan deltas to test the influences of gradients, stream power, lake level, and sediment supply. Secondly this study set up the modern depositional environment of Baiyang River S2S system, which includes the deep-time fan delta regions as sink areas. Then it discussed the influence of precipitation and gradient with another SFM approach, Badlands. Finally, it concluded the insights into the controls on deep-time coarse-grained fan deltas based on the observation from the modern S2S system. The results indicate that decreasing floods will generate regression without slope breaks and the generated fan deltas are brush-like while decreasing sediment supply results in regression with slope breaks and lobe-like fan deltas. High stream power is highly efficient to transport gravels across long distance. In the modern Baiyang River S2S system, high gradient and high precipitation can both enhance erosion, deposition, and channel network density. High precipitation promotes the transport of deposits more significantly while high gradient increases erosion more evidently. The observation that high precipitation and high gradient leads to high stream power in modern system indicates that high stream power was the key to transport gravels across long distance during the humid early Upper Wuerhe. Denudation is positively related to precipitation in modern system, thus the regression was resulted by decreasing stream power and sediment supply due to dry climate in late Upper Wuerhe.

Challenging the maximum run-up height paradigm for turbidity currents interacting with containing topography

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Seafloor topography influences turbidity current behaviour, leading to distinctive turbidites. Understanding the interaction between turbidity currents and topography, especially the maximum run-up height and its geometry on the containing slopes, is critical for the prediction of particulate and microplastic distribution and reconstruction of the physiography of deep-water basin-fills. The wide range of flow regimes, and topographic configurations, means that experimental approaches are needed to advance our understanding. However, previous experimental studies have been conducted in narrow 2D flume tanks or in large 3D tanks with partially containing topography. Here, we perform 18 scaled 3D physical experiments in unconfined settings where the flow is fully contained by a rigid confining slope. This set-up allows investigation into the effects of different topographic configurations, incidence angle of the current to the slope, and slope gradient, on the maximum run-up height and its geometry on the containing slopes. Key results include: (i) a lower incidence angle results in a lower maximum run-up height; (ii) The maximum run-up height for a slope of 30˚ is higher than that for a 20˚ slope, which paradoxically is higher than that for a 40˚ slope, when the incidence angles are kept uniform; (iii) a lower incidence angle leads to an initial increase in the rugosity of the run-up height geometry and subsequently a decrease in the rugosity; and (iv) the rugosity of run-up height geometry for a slope of 30˚ is the highest compared to that for 20˚ and 40˚ slopes. Results have important implications for the prediction of the particulate and microplastic distribution patterns in modern deep-marine environments and can provide insights into the process controls on 3D onlap termination styles, which can be applied to the interpretation of exhumed successions.

Seasonal erosion and accretion patterns of estuarine tidal flat and associated mechanisms: A case study from tidal flat of Minjiang River estuary

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Tidal flats are fine-grained sediment deposits formed under tidal action, widely distributed worldwide, and play a crucial role in carbon sinks and coastal protection. With the reduction of sediment flux delivered by river to ocean, the pattern of erosion-accretion in estuarine tidal flats has changed, which directly affects the function of tidal flats. It is urgent to conduct research on the short-term erosion-accretion process of estuarine tidal flats, in order to provide scientific support for evaluating tidal flats' functions. According to the sediment dynamic parameters observations conducted on the tidal flat of Langqi Island at the Minjiang River estuary in Fujian Province during different seasons, as well as the grain size analysis results of surficial sediments, the surficial sediments of the tidal flat of Langqi Island are mainly composed of fine particles of silt and clay in summer, and coarse particles of sand and silt in winter. The general pattern of erosion-accretion in the tidal flats of Minjiang River estuary is characterized by accretion in summer and erosion in winter, and the variations in erosion and accretion in the middle part of the intertidal zone are greater than those in the lower part of the intertidal zone. In winter, the net flux of suspended sediment near bottom is mainly transported seaward within a tidal cycle, while in summer, it is mainly transported landward. In summary, the seasonal variations of erosion-accretion pattern of the tidal flats in Minjiang River estuary are mainly controlled by hydrodynamic processes: in winter, strong wave action causes significant resuspension of surficial sediment, which is transported seaward by currents, leading to erosion of the tidal flat; in summer, the wave action is weak, and the suspended sediment occurs settling due to low shear stress and is transported landward by current, leading to accretion in the intertidal zone.

Logging evaluation of lamina structure and reservoir quality in lacustrine shale: The Permian Fengcheng Formation in Mahu Sag, Junggar Basin,China

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The Fengcheng Formation in the Mahu Sag of the Junggar Basin is composed of a set of fine-grained sedimentary rocks, which show strong heterogeneity by alternating dolomite lamina, siltstone and organic matter laminae. The lamina structure type has been identified as massive, layered and laminated in this study, according to core observations in terms of the density of the laminae and the overlapping relationships. High-resolution processing is also performed on dynamic image log data to form slab images for recognizing the various types of lamina structures. Compared to core slab photos, slab images offer an excellent thin-layer resolution of up to a millimeter in scale and can effectively identify the lamina structure of the shale reservoir. There are no evident beddings on the core of the massive pattern, and the slab image shows a bright or dark block pattern. There are centimeter-level felsic bands of fine silt sand on the thin-layered sedimentary fabric core, and the slice image shows a band-like pattern. A large number of millimeter-level dolomitic laminae are enriched on the core of the laminated type, and the slab image shows millimeter-level light and dark lamina. Slab images were used for the division and identification of lamina structures in a single well. Then, the relationships between the three types of lamina structures and the two-dimensional nuclear magnetic resonance logs and oil test data were recorded. The results show that massive and laminated reservoirs show low porosity and movable oil content. Conversely, the layered type is bimodal with high porosity and movable oil content. Therefore, the more significant the proportion of layered types in shale reservoirs, the higher the quality of the reservoir. The present study is intended to identify lamina structure-controlled reservoir quality and oil accumulation and to provide insights for the exploration and development of shale oil.

The method and applications of seismic sedimentary structure in shallow-water deltas.

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The exploration of thin sand layers in shallow-water delta areas has emerged as a significant new frontier in lithological oil and gas reservoir exploration. The thin and rapidly changing nature of sand bodies in shallow-water deltas, coupled with the difficulty in identifying their depositional structural characteristics, has constrained the exploration and development of such sedimentary bodies. Taking the Fangcao Lake area in the Mosuowan uplift of the Junggar Basin as an example, a comprehensive geological-geophysical analysis and an in-depth seismic sedimentology analysis were conducted. Three key technologies, namely "High-Low Frequency Cyclicity Waveform Separation," "Removal of Layer Slicing Interference Effects," and "Integration of Geological Bodies with Sedimentary Background Attributes," were employed to study the seismic sedimentology characteristics of shallow-water delta regions and summarize the sedimentation patterns of shallow-water meandering river delta.

The research reveals: 1. In the Fangcao Lake area, the Lower Cretaceous Qingshuihe Formation exhibits multiple fourth-order sequences, reflecting periodic changes in the lake plane; 2. Sub-channel and fan-shaped sand bodies are widely developed in the study area ; 3. In the Fangcao Lake area of the Junggar Basin, the Lower Cretaceous Qingshuihe Formation presents three sets of reservoir-seal combinations within the shallow-water meandering river delta depositional system, representing a promising exploration layer.

The application of seismic sedimentology identification technology for thin sand layers in shallow-water deltas has facilitated drilling in high-risk well locations, achieving favorable exploration results. This has provided technical support for increased storage and production in the region while offering valuable insights for identifying thin sand layers in similar areas.

The fate of terrestrial organic matter at a fault-controlled rift margin influenced by lacustrine and Gilbert-type fan deltas

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Organic matter (OM) burial in lakes has been identified as an efficient sink in the global carbon cycle. Abundant input of terrestrial OM leads to high variability in terms of origin and composition of organic carbon, but its production, transport, and deposition over geological scales have been overlooked in prior studies. Here, the OM source and concentration of the Lower Cretaceous Shahezi Formation (Songliao Basin, NE Asia) were investigated in a framework of tectono-sedimentary and paleoclimate changes. Multi-independent proxies (correlative reflected light and electron microscopy, bulk pyrolysis, Ro, TOC/TN, and δ13Corg) unveil the dominance of terrestrial OM (gas-prone, type III/IV kerogen) within the highly mature mudstones. The prevailing warm, humid, and boreotropical climate during the deposition of the Shahezi Formation promoted terrestrial primary productivity and hydrologic cycle in the rift lake catchment, which, in turn, led to a sufficient source of terrigenous OM around the lake. The rapid subsidence and development of fault-bounded syncline associated with syn-rift tectonic activity, facilitated the terrestrial OM influx by opening the sediment transfer zones and enlarging the lake accommodation space. The progradation of Gilbert-type fan deltas, forming along the steep syn-rift basin slopes, served as a key pathway for transporting terrestrial OM debris from the hinterland towards the lakeshore to profundal facies. The lake level rise and submergence of coastal peat swamps amplified the input of lant plant detritus into littoral to profundal sediments. This is supported by the wide dispersion of clay- to granule-sized terrestrial OM particles within the finely laminated black mudstones. This study proposed a basin-scale model of the production, transport, and deposition of terrestrial OM in active rift basins. As the results also speak to the effectiveness of carbon burial in fine-grained sediments, it may contribute to a better understanding of the palaeolake environment and biogeochemical cycling.

Mineralization mechanism of ancient Precambrian microbial dolomites in Tarim Basin (NW China)

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There have two hotting issues about dolomite: (1) in abiotic laboratory, it is impossible to synthesize dolomite under normal Earth's surface conditions (i.g., “Dolomite Problem”); and (2) Precambrian has abundant dolomite, but rarely has fossil microbes (i.g., Precambrian Enigma). Ancient Precambrian microbial dolomites are subject to various diagenesis, altering their original microstructure. The mineralization and formation mechanism of Precambrian microbial dolomites remain to be unresolved.

Detailed petrology, SEM-EDS and laser confocal analysis of Qigebulak Formation (560~542 Ma) microbial dolomites were carried out. Qigebulak Formation consists of stratified, columnar, and domal stromatolites, and clotted thrombolite. Most stromatolites are composed of micrite dolomites. Geochemical results show that their isotopic and elemental compositions of microbialite matrix and fibrous cement are consistent with the coeval seawater. This suggests the special Neoproterozoic "aragonite-dolomite sea" environment, which is conducive to precipitation of "primary dolomite". Laser confocal results show that organic materials are distributed in the dark layer of the stromatolites. Some typical filamentous, rod-shaped and reniform “suspected” microbial EPS were observed in the matrix, consistent with the filamentous and coccidium cyanobacteria observed in modern microbialites. SEM-EDS further conformed the micron-scale in situ EPS, including sheet, spiral, tubular, plaque, and flower-like. These EPS are rich in C, N, S, Fe, Na, Cl, K, Mg, and Ca. EPS consists of nanoscale dolomite crystals. In addition, halite crystals were also detected around EPS similar to Shark Bay.

Overall, we inferred that Qigebulak Formation coincide with the model of microbe-induced dolomite precipitation. Thus, we establish the mineralization model and formation mechanism. The cyanobacteria community developed widely in the Late Ediacaran, and produced a large amount of EPS, which first induced the formation of micrite dolomites, forming basic stromatolites or clotted thrombolite. Then, under the hypersaline environment, EPS was more conducive to bonding and trapping particles to form “aggregated stromatolites”.

Geothermal potential of fluvial sandstone reservoirs: a case study from the Dutch subsurface

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Fluvial sandstone reservoirs hold great potential for long-term geothermal energy exploration. Their reservoir properties place them among the most productive subsurface reservoirs on the planet. Nonetheless, the heterogeneity of fluvial reservoirs causes lateral and vertical quality variations that require careful consideration when planning a geothermal well.

A case study for fluvial geothermal sandstone reservoirs can be found in the West Netherlands Basin. Here, the Late Jurassic fluvial deposits of the Nieuwerkerk Formation form the main geothermal target. The depositional environment of its fluvial system is strongly impacted by the development of the basin during the Mesozoic; multi-phase rifting produced a NW-SE elongated basin that became inverted and uplifted during the Late Cretaceous and Cenozoic. The Nieuwerkerk Formation was deposited during the last major rifting phase. The interplay of faults controlled the creation of accommodation space, thus influencing the architecture of the river system. As a result, the heterogeneous distribution of the sandy facies has an unpredictable nature, causing lateral and vertical variations in porosity, permeability and net-to-gross ratios.

A renewed seismic interpretation, aided by seismic attribute analysis and well data, provides a better reconstruction of the river system over time. This not only allows us to understand the interaction between the fault activity and the river system, but it also contributes to the understanding of the stratigraphy of the river system. These factors contribute to a better understanding of the quality variations of a river system in an inverted rift basin. As a result, this study helps reduce the risk of geothermal well planning for fluvial sandstone reservoirs in inverted rift basins.

ICHNOFACIES ANOMALIES: NAVIGATING THE ABSENCE OF THE ARCHETYPAL CRUZIANA ICHNOFACIES IN THE LOWER DEVONIAN TALACASTO FORMATION OF THE ARGENTINEAN PRECORDILLERA

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The Devonian was signaled by multiple biotic crises. The Lower Devonian Talacasto Formation of Argentina is characterized by black, parallel-laminated mudstone passing upwards into siltstone and very fine- to medium-grained sandstone, ranging from shelf to upper shoreface. This example differs from the traditional ichnofacies model of wave-dominated environments in the absence of the archetypal Cruziana Ichnofacies. Two ichnofacies were recognized: the distal Cruziana Ichnofacies and the Skolithos Ichnofacies. The former, in lower offshore to lower shoreface deposits, is dominated by Phycosiphon incertum and Zoophycos isp., with subordinate Nereites missouriensis and Chondrites isp. The Skolithos Ichnofacies, of lower/middle shoreface deposits, is dominated by Rosselia socialis and subordinate Skolithos isp. and Arenicolites isp. The absence of the archetypal Cruziana Ichnofacies is anomalous because: (1) the upper offshore deposits that typically host this ichnofacies are well preserved and contain the distal Cruziana Ichnofacies instead, (2) the macrofauna (mainly brachiopods and trilobites) suggests normal-marine salinity and oxic bottom waters, and (3) the Early Devonian is not known as a time of mass extinction, which may be deemed responsible for the absence of this archetypal ichnofacies. Unravelling the interplay of ecologic and taphonomic factors would be crucial to understand this anomaly. By maintaining a connection with the sediment-water interface, the producers of Zoophycos isp. and Chondrites isp. were able to penetrate poorly oxygenated sediment, providing that the bottom waters were dysoxic or oxic. However, Phycosiphon incertum and Nereites missouriensis lack a connection with the sediment-water interface, therefore implying at least dysoxic interstitial waters. This association may suggest a relatively shallow redox discontinuity surface. Also, taphonomic constraints may be invoked. In this scenario, the high degree of bioturbation (BI=5-6) implies long colonization windows that may have allowed the mid- to deep-tier tracemakers to obliterate any possible shallow-tier trace fossil characteristic of the archetypal Cruziana Ichnofacies.

First coral colonization in the Red Sea – Burdigalian bioherms, not reefs?

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The Red Sea started to open in the Oligocene and experienced its first marine incursion in the Burdigalian. The bioherms representing a first phase of normal marine conditions in the Red Sea were constructed by low-diverse corals during the Burdigalian to Langhian. Conditions were strongly influenced by terrestrial sediment input into the narrow basin, and temperature and CO2 levels were higher than today. Here we report on exposures or coral-rich carbonates from the Red Sea coast in Saudi Arabia. The coral bioherms of the Burdigalian of Umluj, similar to previous records from the upper Oligocene and LowerMiocene in the Mediterranean, have a markedly different appearance to those of modern tropical coral reefs. They form stacks of mounds along a slope gradient and are embedded in fine to coarse-grained sediment with a prevalence of fine sediments, which is in accordance to the position in the meso-oligophotic, rather than fringing, patch or lagoonal back reefs at shallower settings. The abundance of massive growth forms as well as the microfauna assemblage also points meso-oligophotic conditions by analogy with ecological assemblages of corals in modern reefs. The high compositional similarity between the coral assemblage from the Wadi Waqb Member and the living coral fauna of the Red Sea suggests that coral community structure also was similar. However, the succession studied here predates the Middle to Late Miocene global cooling trend that previously has been suggested to have induced an upward migration of coral ecosystems into well-illuminated settings, going along with a rapid diversification of the Symbiodiniaceae. The Burdigalian coral build-up here give opportunity to study the community structure and functioning of pre-modern type coral ecosystems under terrestrial influence and high-temperature and CO2 conditions.

Red Sea anoxic brine pools act as taphonomic traps for organic remains

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The preservation of organisms with labile potential of post-mortem fossilization is crucial to understand evolutionary and ecological aspects of life on Earth. Since the Neoproterozoic, paleobiological archives (Lagerstätten) bear important information. However, little is known about modern analogues. Here we report on a case from bathyal depths in the northern Red Sea (Saudi Arabia), surveyed in 2023 during RV Meteor cruise 193. The unnamed brine pool discovered in 2019 by a KAUST-led oceanographic campaign fills a depression at 25° 08,809' Lat N and 36° 57,798' Long E in 630 m water depth. CTD profiles document a drastic excursion of salinity from the Red Sea-typical 40.6 PSU to in excess of 180 PSU, while temperature increased from 21.5°C to 23°C, and pH dropped from 8 to 6. This abnormally high salinity is thought to be driven by tectonically-controlled seawater circulation leaching subsurface Miocene salt deposits. An Remotely Operated Vehicle (ROV) survey imaged the 'beach' of the pool, revealing abundant, low-diversity megabenthic (mostly shrimps) and nektonic (fish) life, which was absent inside. A box core from the bottom of the brine pool revealed nanno-foram-pteropod ooze, i.e., deeü Red Sea standard sediment. The preservation of most skeletal remains was exquisite, with pteropod aragonitic shells still translucent. Other holoplanktic shells were present but virtually no benthic vestiges were detected. One remarkable exception was the occurrence of partly decayed seagrass leaves, some with epiphytic foraminifers attached. The brine acts as preservational archive also of nektonic organisms (fish). Teeth, bones, scales and a few complete skeletons with decayed soft tissue were identified from various deep-water teleosts. Seemingly representing an extreme and rare case of actualistic Lagerstätte, the brine pool could be a model for past settings with hyperhaline conditions, such as at earlier phases of continental rifting or the upper Miocene Mediterranean basin.

Rheological Control on Structural Styles in the Cleveland Basin, NE England

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The Cleveland Basin in North Yorkshire lies above and is super-imposed on the western margin of the Anglo-Polish Basin, a major intracratonic basin extending across NW Europe that has proved to be an important petroleum super-basin over the past 60 years. As the Anglo-Polish Basin nears the end of its life as a petroleum province, there is an opportunity for onshore depleted gas fields to be repurposed and for hydrocarbon subsurface data and infrastructure to be re-used to face the energy transition.

Using a variety of open-access and proprietary subsurface datasets, holistic mapping of the subsurface has revealed that two different and contrasting structural styles characterise the sub- and supra-salt sections in the Cleveland Basin, the creation of which are heavily affected by evaporite thickness and facies variability in the Permian Zechstein Group. Towards the west in the Vale of Pickering, the basin experienced a net extensional stress regime as a result of Mesozoic rifting and activation of the Flamborough Head Fault Zone which detaches down at the Z1 anhydrite. Meanwhile, towards the northeast and in the vicinity of Ebberston Moor, the basin is in a net compressional stress regime as a result of Cenozoic compression, creating a fold-and-thrust belt that only affects the Permo-Carboniferous section up to and including the Z2 evaporite, unaffecting the overlying Mesozoic which was only gently folded. The Vale of Pickering also experienced Cenozoic compression/inversion, but it was not intense enough to overprint the precursor Mesozoic rift grabens/half-grabens.

The outcome of the study has not only enabled us to understand the various geological options that lead to conventional hydrocarbon prospectivity, but also the various opportunities that may help decarbonise NE England.

Phases of transformation ice margin valley to river valley system – a model of postglacial evolution of the Warta River system, west-central Poland

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At the turn of the Last glacial Maximum (LGM) and Late Glacial on the Polish Lowlands, the river network had a different flow pattern from the present one. Proglacial water from melted ice sheet as well as extraglacial water flowing from the south could not run to the north due to presence of the Scandinavian Ice Sheet (SIS). Therefore, an outflow towards the west prevailed along the ice margin and ice-marginal valleys (IMV) formed filled with mainly glaciogenic deposits. Such depositional basin formed in the central Wielkopolska region in Poland. In the final part of the LGM the Warta River flowed towards the west. Then, after a partial recession of the SIS, the river changed its course toward the north and began to form a normal river valley with a system of terraces.
Climatic changes occurring at the very end of the LGM modified river systems, including the Warta River system. This resulted in a gradual cutting into the subsoil and a change in the style of channel development. GIS analyses within the Śrem Basin, central Wielkopolska region, allowed to identify the seven phases of the Warta River transformation at the turn of the late Pleistocene and Holocene. The evolution was shown from the IMV phase through the barided river, anastomosing river, the phase of Late Glacial great meanders to Holocene small meanders. Results of optically stimulated luminescence and radiocarbon dating from several sites within the basin indicate the beginning of the river valley transformation at the turn of the Late Pleniglacial – Late Glacial and then in the Allerød-Bølling and the Younger Dryas. It can be concluded that the evolution of the valley was influenced not only by climatic factors, but also by isostatic movements of the basement and the local geological and geomorphological structure.

Textural evolution in soil carbonates: what do calcrete textures really mean?

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Two contrasting textural groups have been confirmed in numerous studies of low Mg calcite (LMC) calcrete soils and paleosols. One type (alpha calcretes) is composed of predominantly simple crystalline mosaics, often of rhombohedral calcite, in contrast with those that display a range of biologically induced microfabrics (beta calcretes). These differences have been proposed as due to climatic-vegetation or substrate controls with beta types being associated with assumed less arid climates and carbonate hosts, and alpha calcretes with more arid climates and siliciclastic hosts. Beta calcretes are typically composed of nonequilibrium LMC morphologies such as needle fibre calcite, nanofibres and mesocrystalline biomineral forms. Such textures have very high porosity and exceptionally high crystal surface area-to-volume ratios, making them susceptible to dissolution, and the subsequent nucleation and overgrowth by more stable rhombohedral crystal morphologies. Alpha mosaics also reveal evidence of multiple dissolution and overgrowth events. In less well developed pedogenic carbonate accumulations, beta textures are commonly more prevalent, whereas more extensive carbonate accumulations have alpha textures. This difference suggests a preservational effect whereby beta textures, having experienced shorter residence times in the soil, undergo fewer dissolution-precipitation cycles, and hence a greater potential for nonequilibrium crystal forms to be preserved, whereas alpha textures are the product of a likely greater number of such cycles and more loss and overprinting of earlier calcite forms. In addition, localised zones of enhanced biological activity such as the rhizosphere also promote the likelihood of beta textures being formed and preserved. The use of the term recrystallisation is reviewed in the context of carbonate precipitation in soils.

Coupling mechanism between sea level changes and pore heterogeneity of marine shale reservoirs driven by astronomical orbital cycles: Lower Silurian Longmaxi shale in the Upper Yangtze area, South China

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Marine cycles driven by astronomical orbital periods, may reflect sea-level fluctuations, which considerably influence organic matter (OM) accumulation, redox conditions, and terrigenous input, and subsequently impact the heterogeneity of shale reservoirs. This study uses multivariate analysis to examine astronomical orbital cycles and sea-level fluctuations, and investigate coupling mechanism between seal level changes and pore heterogeneity in Lower Silurian Longmaxi marine shale reservoirs. We conducted a high-resolution cyclic stratigraphic study of the GR series and performed associated geochemical analyses. Milankovitch cycles were identified, including ~1.2 Myr obliquity, ~ 405 kyr long eccentricity, and ~95 kyr short eccentricity cycles. Climate change driven by ~1.2 Myr long obliquity cycles resulted in two climate fluctuations (hot-humid and dry-cold), causing eustatic changes with two transgression-regression cycles (2 transgressive system tracts (TST) and 2 regressive system tracts (RST) identified. The changes in sea level during these periods considerably influenced the heterogeneity of shale pores, leading to variations in pore types and characteristics in response to sea-level fluctuations. For instance, during TST1, deglaciation occurred, causing a rapid rise in sea level and the deposition of organic-rich shales in a deep-water anoxic environment with limited terrigenous influx. This environment, combined with abundant biogenic silica, contributed to the accumulation of OM and promoted porosity, making organic pores dominant during the TST1 to RST1 period. Subsequently, the Upper Yangtze area shifted to a semi-restricted dysoxic - oxic deep-water shelf with the fall in sea level. This change resulted in decreased paleoproductivity and increased terrigenous influx, directly leading to reduced pore development, with inorganic pores becoming the main pore type during the TST2 to RST2 period.

Integrated Reef-shoal Complexes Characterization of Seismic with Geology Modeling: A Case Study in Tarim Basin, NW China

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Characterizing reef-shoal complexes reservoir features remains challenging due to complexities in terms of proper identification and structure description,and methods necessary to integration of geology and seismic models.Cambrian reef-shoal complexes reservoir are well outcropped in Tarim basin,NW China. Based on measurement,thin sections analysis and geochemical analysis, the inner structure and lateral distribution of the reef-shoal complexes reservoir were discussed and a geologic model was established.The geologic model shows that reef-shoal complexes is controlled by transgression-regression cycles and structure.The large algal reef and para-laminar high-energy grain shoal is development in the upper of regression cycles and located at structure tops-slopes, the patch reef and the lenticular low-energy shoal is development in the lower of regression cycles and located at structure lower slopes.The main reservoir spaces are corroded vug and recrystallized intercrystal pore and algae-frame pore,and the reservoir porosity ranges form 1.37% to 9.72%,with an average of 4.5%.The shoal reservoir is much larger scale than the reef,the average thickness of shoal reservoir is 40m to 50m and the width of reservoir is 20km at least.From geologic model to forward seismic modeling,the result suggests that, reef-shoal complexes features can be associated with seismic attributes and reflection structure.Reefs are characterized by low frequency,middle amplitude,poor continuous,mound reflections,and shoals are represented by high frequency,high amplitude, moderately continuous,mat reflections.By contrasting modeling results and subground seismic features with well calibration,there are similar seismic attribute of reef-shoal complexes.Reservoir properties can be differentiated based on the tier of the seismic anomaly and the genetic classification of reef-shoal complexes.So build mathematical formula for specific ranges of amplitude are classified in the seismic volume to capture the distribution of reef-shoal complexes reservoir.From a geologic modeling perspective,seismic reef-shoal geobodies can be imported as deterministic objects into the geologic model and condition the distribution of reef-shoal complexes reservoir that is below seismic resolution.

Terrigenous hot spring sinters and submarine hydrothermal smokers record changes of organic molecules: Implication for the search for biomolecules on Mars

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The targeting of Mars Sample Return (MSR) project is one of the most challenging works in human history, which aims at searching possible biomolecules on Mars, as organic molecules are readily degraded under great amounts alteration by cosmic irradiation or temperature shocks. However, Martian hydrothermal silica at e.g., Nili Patera provides an outlet for the inner heat of Mars' core, and offers an exceptional opportunity for preservation of biomolecules. Earth's analogues such as siliceous sinters of terrigenous hot springs and sulfide ores of submarine hydrothermal smokers contain a series of complex organic molecules that characterise a gradient of secondary alteration of the pristine organic materials. Here we report high resolution molecular mass spectral data of the extracts of silica sinters from Tengchong, near the Indo-Eurasian collisional margin, southeastern Tibetan Plateau and and sulfide ores from the seafloor, Southwest Indian Ridge. Distinct changes in molecular compositions (n-alkanes, isoprenoids, methylalkanes, acids, ester, etc.) indicate various biological origins. The prominent molecular changes are shown by recalcitrant polycyclic aromatic hydrocarbons (PAHs) and heterocyclic compounds. The PAHs and S- and N-containing compounds decrease with proximity to the center of hot springs and hydrothermal vents showing a strong temperature correlation, but those side-chained molecules increase. The double bond equivalent and the carbon number of the O and N class species increase with proximity to the spring or vent center. The data supports that the dearomatization and dealkylation processes dominate the hydrothermal alteration in these Earth's analogues. In addition to sample lithology and fluids migration, the distance to the spring or vent center may control the state of recalcitrant organic molecules that can survive in analogue extreme environments on Mars. Therefore, a more promising sampling location for detection of primitive molecules may be slightly away from the center of site like the Nili Patera and others.

The bar-finger-type lobate delta: formative processes and depositional architecture

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Lobate river deltas are commonly considered as those develop numerous distributary channels and sheet sands, attributed to frequent channel bifurcations. In contrast, digitate deltas consist of bar fingers and accompany with marshes and interlays, attributed to channel avulsions. This paper provides a novel model for bar-finger-type lobate delta, integrating of satellite image analysis of modern deltas, shallow core and GPR profile studies of the Ganjiang Delta in the Poyang Lake (China) and 'Delft3D' simulations. Our data and analyses show that the bar-finger-type lobate delta, compared to traditional lobate delta, consists of numerous bar fingers without a sheet sand, which are separated from lenticular interlays. Distributary channels in bar-finger-type lobate deltas are stable and lowly sinuous, and they incise central mouth bars and elongate downstream, resulting in a rough delta shoreline. Thick and cohesive levees are deposited at the sides of distributary channels, which hold back most of bifurcations. Bar-finger-type lobate delta hosts a lobate shape by an initial bifurcation, and a sequence of convergences and avulsions of multiple bar fingers. A fine-grained sediment supply and high-discharged water supply within a humid climate prefer to develop bar-finger-type lobate delta. It is approved by modern and ancient records where a large-scaled permanent river flows into lake or bay. This work provides insights into natural and artificial shallow-water digitate delta growth and provides new quantitative facies models for shallow-water deltas.

The sedimentary source-to-sink analyses of the Paleogene large axial delta systems in the Liaoxi Sag of the Bohai Bay Basin

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Sediment routing from source to sink plays a crucial role in retaining tectonic and environmental information of the source area, significantly influencing sedimentary sandbodies within basins. In the Bohai Bay Basin's Liaoxi sag, there was a shift from a small west-east oriented delta in the Paleogene Shahejie Formation to a larger north-south oriented axial delta during the Dongying Formation, raising questions about the sediment's origin and the delta's evolutionary history. This study integrates sandstone composition, heavy mineral, and detrital zircon U-Pb dating to trace the sediment sources and understand their impact on delta evolution. The increase in volcanic rock fragments from the Shahejie to Dongying Formations indicates a stronger sediment supply from the Yanshanian orogeny igneous rock source. The detrital zircon ages, light mineral compositions, and heavy mineral assemblages vary significantly across the delta's reaches. The upper delta shows Mesozoic Yanshanian orogeny signatures with Archean zircon ages, the middle reaches are mainly Archean with Mesozoic Yanshanian ages, and the lower reaches have more Archean and fewer Mesozoic Yanshanian zircon ages. Heavy mineral and lithic data corroborate these findings, indicating a dominance of igneous rock-sourced detritus in the upper reaches and metamorphic rock-sourced detritus in the lower reaches. This evidence collectively suggests that the formation of the extensive axial river delta during the Dongying Formation was not the result of a single-source system. Instead, it was shaped by multiple sources contributing diverse mineral compositions and detrital zircon age profiles. The formation of a large paleo-drainage system during the Dongying Formation, driven by the convergence of multiple sources, led to the development of an expansive delta spanning over 100 kilometers across the center of the basin. Our study highlights the significance of source area size in controlling the distribution and scale of sandbodies in the depositional sink.

Sedimentary model of microbialites at several scales and its distribution in the Ediacaran Dengying Formation, central Sichuan Basin, Southwest China

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The successful exploration of natural gas in the microbial reservoirs of the Ediacaran Dengying Formation reveals the great resource potential in the central Sichuan Basin. However, the depositional characteristics and its distribution of microbialites can be further delineated at multiple scales with the progress of exploration. Based on numerous outcrop and core observations with petrological descriptions of polished slabs and thin sections, we established the depositional model of microbialites at different scales. Two types of microbialites, stromatolites and thrombolites, were identified in the Ediacaran Dengying Formation in the Sichuan Basin. Despite that, non-skeletal grains such as intraclasts, oncoids, ooids, and peloids have also been observed in the Dengying Formation. These grains are classified as grainstone, packstone, wackestone and mudstone. Based on these petrological characteristics, eleven lithofacies and three sedimentary cycles have been identified, which correspond to three depositional environments, including peritidal, shallow subtidal, and lagoon environments. In the peritidal environment, the multi-stage microbial build-ups are observed with the frequently occurrence of the fenestral and teepee structures. Intraclastic grainstone-packstone deposited in the shallow subtidal environment, which could develop lens-shaped bioherms as macroscopic build-ups. The lagoon cycle is dominated by medium-to-thick bedded dolo-mudstone in the lower part. The thickness of microbialites evolves to thin lay upwards and consequently decreases the development of microbial build-ups. The second member of the Dengying Formation is dominated by peritidal and shallow-subtidal cycles, more than 80% in thickness, in the central Sichuan Basin. In the fourth member of the Dengying Formation, the microbialites in the platform margin account for nearly 70% of the stratigraphic thickness. In contrast, the lagoonal dolo-mudstone dominates the inner platform, with microbialites accounting for only about 40% in thickness. Prospectively, this study can provide a detailed framework for the distribution of microbialite-dominated reservoirs in the Ediacaran Dengying Formation of the central Sichuan Basin.

Spatiotemporal variations in formation conditions of cryogenic brines: Insights from aragonite cements in New Harbor, western Ross Sea, Antarctica

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Cryogenic-brine precipitated carbonates (cryo-brine carbonates) have proven to be a valuable proxy for tracing the origin, nature, and distribution of Cenozoic brines that reside beneath McMurdo Sound (MMS) and adjacent McMurdo Dry Valleys (MDV), Antarctica. Of particular significance is the predominance of cryo-brine aragonite cements found in several stratigraphic sections in this region, reflecting the initial chemistry and conditions under which the brines formed. To fully explore this aspect, this paper presents a comprehensive examination of cryo-brine aragonite cements in all sediment cores recovered in New Harbor, an embayment that connects the MDV and MMS. Petrographic and isotopic analyses of the cements reveal a more diverse range of brine-forming environments in the glacial outlet system during the middle Miocene Climatic Transition and the Early–Middle Pleistocene Transition than previously understood. These environments span subglacial and ice-contact proglacial lakes to sub-ice-shelf fjords, occurring as cold-based, continent-sized Antarctic ice sheets expanded over the continental margin. Subsurface infiltration of the brines triggered almost instantaneous precipitation of aragonite cements below the sediment-water interface at near freezing temperatures. Driven by the hydrologic gradient, the brines facilitated slow yet pervasive precipitation of an unusual form of aragonite characterized by coarse, blocky and poikilotopic morphologies—distinct from the typical acicular and fibrous aragonite dominating near-surface strata. The oxygen isotopic compositions of brines derived from the aragonite vary among different environments, displaying a basinward increasing trend from ~ –30 to –5‰ VSMOW. The ^{18}O depletion is primarily controlled by the availability of periodic water replenishment and the relative contribution of seawater versus meltwater during the cryoconcentration process. The ubiquity of brine-forming environments on the Antarctic continental margin suggests their potential existence in ancient ice ages, which may be identified by distinct cryo-aragonite cement patterns documented in this study.

Types and genesis of deep-water gravity-flow sedimentary lithofacies of the Cretaceous Ngamring Formation in the Xigaze forearc basin, Tibet

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The Cretaceous Ngamring Formation in the Xigaze forearc basin in Tibet serves as an excellent example for the systematic study of deep-water gravity-flow sedimentary lithofacies and their formation and evolution processes in marine environments. The deep-water gravity-flow deposits in the study area can be primarily categorized into conglomerate facies, gravelly sandstone facies, sandstone facies, siltstone facies, argillaceous sandstone facies, mudstone facies, and chaotic deposits facies. Conglomerate facies can be divided into massive bedding matrix-supported conglomerate facies and graded bedded grain-supported conglomerate facies. The sandstone facies can be divided into massive bedded sandstone facies, graded bedded sandstone facies, parallel bedding sandstone facies, and cross-bedded sandstone facies. The argillaceous sandstone facies can be divided into massive mud-clast rich argillaceous sandstone facies and mud-clast poor argillaceous sandstone facies. The regular combination of conglomerate facies, gravelly sandstone facies, sandstone facies and chaotic deposits are indicative of gravity flow deposits in gravelly channels. They are most typical in the Kadui section and Gangjian Village section. The regular combination of conglomerate facies, gravelly sandstone facies, sandstone facies, gravelly mudstone facies, and chaotic deposits are the sedimentary product of the gravity channel-lobe transition zone, which is the most typical in the Sangsangzhen section. The regular combination of sandstone facies, argillaceous sandstone facies, and siltstone facies are indicative of lobe deposition, which is most typical in the section along the south of the highway in Xigaze. The regular combination of sandstone, siltstone, and mudstone with different thicknesses is the product of levee deposition, which is well-developed in both the Kadui section and the Jianlanggou section. The overall sediment composition of the Ngamring Formation is thick in the middle and thin above and below. The vertical stacking pattern may undergo an orderly evolution process from hemipelagic sedimentation, slump mixed accumulation, gravel channel, sandy channel and then sheet sedimentation.

Types of deep-water fine-grained sediment gravity-flow deposits and their trace fossil records in the Cretaceous Ngamring Formation in the Xigaze forearc basin, Tibet

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The Cretaceous Ngamring Formation in the Xigaze forearc basin of Tibet provides an excellent example for the systematic exploration the sedimentary process of fine-grained gravity-flow and the associated patterns of trace fossil development. The thickness of sheet sediments in the study area ranges from 0.3-13 cm (297 layers), with an average thickness of 2.4 cm. Three types of sheet sediments are mainly developed: low-density turbidity current deposits, hybrid event beds, and transitional gravity flow deposits, and dominated by transitional gravity flow deposits. The low-density turbidite deposits showed obvious normal grading. Hybrid event beds are characterized by bipartite structures. The transitional flow deposits are also featured by bipartite structures, with normal ripples, large-scale ripples, and low amplitude sediment waves in the low part and overlay by argillaceous sandstones. Large-scale ripples, and low-amplitude sediment waves show obvious inverse grading, which is different with normal ripples. Trace fossils are common in transitional flow deposits, primarily dominated by Nereites, indicating a deep-water sedimentary environment. The sole marks are dominated by Cosmorhaphe with occasional Spirophyton, which belong to Zoophycos. Trace fossils in sandy deposits dominated by Chondrites. The coexistence of Nereites and Zoophycos during the Cretaceous period, indicated that Zoophycos had evolved into deep-water trace fossils. The widespread distribution of trace fossils at the base of transitional flow deposits indicates that an environment rich in organic matter and mud is conducive to the survival of deep-water benthic organisms on one hand and facilitates the transition from turbidity flows to transitional flows when interacting with the substrate on the other hand. The inverse-graded sedimentary sequence formed by transitional flows is conducive to the preservation of trace fossils at the base.

Paleo-lake Filling Evolution and Associated Hydrocarbon Accumulation of Yanchang Formation, Ordos Basin, China

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Ordos is the most important oil and gas bearing basin in China, and the Yanchang Formation is the most important oil and gas bearing target of the basin, and it reflected a complete evolution of a large inland lake from initial development to final filling.

On the basis of detailed observation and analysis of the Shiwanghe, Yanhe, Yan'an, and Yaoqu outcrops (36 sections) of the Yanchang Formation, with a focus on descriptive sedimentary facies division, facies association analysis, and well logging calibration, a comprehensive stratigraphic histogram on basin level of the Yanchang Formation was systematically established and a new sequence stratigraphic framework was constructed. Then the sedimentary environment and its impact on the development of sedimentary systems were analyzed, regarding to the genesis of thick sand bodies, distribution of source rocks, evolution of lake basins, and their geological significance on oil and gas exploration of the Yanchang Formation.

Hyperpycnal flows constitute an important depositional mechanism that accumulated very thick clastic successions within the Yangchang Formation. During flood periods, the carrying capacity of river is strong and it can transport high-density mixture of water and sediment. When this high-density flow reaches the shore, the sediment transported by the river does not immediately stop and deposit to form the conventional littoral delta. Instead, it acts as a bottom flow originating from the land, plunging into the water and continuing transport to the basin and finally sediment gradually settles in deeper water far from the shore and forming a large scale sand body mainly in the form of tabular to irregular massive sandstone.

Enhanced nitrogen fixation during short-lived global warming in the Late Pennsylvanian icehouse

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The late Pennsylvanian Kasimovian-Gzhelian Boundary (KGB) event recorded prominent perturbations of global biogeochemical cycling, accompanied by significant global warming, marine anoxia, and biodiversity loss. It is critical to understand marine primary productivity and redox mechanism during the KGB warming given that it occurred under an icehouse climate state and may serve as a proper analogue to better understand the deep-time icehouse Earth system. Nitrogen (N) plays a key role in ocean productivity and has potentially significant implications for the global climate system. The variations of nitrogen isotopic composition (δ15N) in marine sediments are related to changes in organic carbon burial and marine denitrification rate during the glacial-interglacial cycles. Here, a high-resolution δ15N record was obtained from three carbonate slope successions in the South China to determine the nitrogen cycling during the KGB warming. Results show that about 4-6‰ negative excursions of δ15N occur immediately below the KGB in the three sections, which are consistent with coeval rapid global warming, expanded marine anoxia, and intensified marine stratified water mass. The marine N cycle involves the effects of N fixation and denitrification on marine fixed-N inventories. The distinct negative excursion in δ15N suggests enhanced nitrogen fixation, which possibly resulted from advanced anoxic conditions during the KGB.

Fine characterization of braided river reservoir architecture with sparse well pattern based on intelligent fusion of multiple seismic attributes

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C-6 Oilfield is one of the most principal oilfields of Caofeidian oil province with hundred million cubic metre of reserves. The third oil group of Guantao Formation (N1gⅢ), the main production zone of C-6 Oilfield, is sand-rich braided river deposit. The architecture and connectivity of braided river sandstones are the key geological factors affecting the development effect of the Oilfield. Calibrated with limited log data, intelligent fusion technology of multiple seismic attributes was introduced to finely characterizes the spatial distribution of the level-4 architecture units of the braided river reservoir. According to log interpretation, N1gⅢ of C-6 oilfield mainly develops two types of level-4 architecture units, namely, channel bar and braided channel. Based on seismic attribute extraction and correlation analysis with lithological and physical parameters, reflection intensity, relative impedance, sweet point, original amplitude, envelop were chosen as intelligent fusion seismic attributes with Deep Feed-Forward Neural Network (DFNN) algorithm under the supervision of porosity. The 3D attribute of DFNN fusion, representative of lithology and petrophysical property, largely improves the detecting ability of braided river sandstone units and their boundaries, and thus can be used to finely characterize the plan and section distribution of braided river fourth-level architecture units. A NE-SW braided flow zone was identified, which could be internally sub-divided into 15 fourth-level architecture units of the braided bar. Distributary channels, another fourth-level architecture units, surrounded braided bar in a narrow strip. The fourth-level architecture interface between the two units played as seepage barriers for fluid migration. The braided bars cut and overlapped one another vertically, forming “big bar and small channel” plan reservoir architecture pattern. The fine characterization results deepened the understanding of the reservoir connectivity of the braided river reservoir with sparse well pattern, which provided direct geological bases for the making of optimized adjustment plan of C-6 Oilfield.

Low-temperature origin of early diagenetic dolomite in early Lake Van sediments

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Expanding the envelope of documented dolomite-forming environments has wide implications for geoscience. McCormack et al. (2018) proposed that early diagenetic Lake Van dolomite from the last 150 ka formed in deep water (low temperature, < 4 °C) in the sediment pores of organic-rich layers, yet this hypothesis remains unverified. In this study, we base the investigation on the data generated by McCormack et al. (2018) covering last 150 ka but extend the record to the entire 630 ka of Lake Van history, including its purported freshwater phase, and we apply the carbonate clumped isotopes (Δ47), a quantitative indicator, to test the hypothesis of low temperature origin of early diagenetic dolomite occurring in Lake Van sediments.

Systematic quantitative X-ray Powder Diffraction data demonstrates there are two different dolomite populations, i.e., a stoichiometric dolomite with 52.0 to 62.7 mol % CaCO3 and a calcian dolomite (degree of ordering of 0.416 to 0.858) with 53.7 to 64.3 mol % CaCO3, showing cyclic occurrence of high enrichments (up to 20%, 80% respectively) along the Lake Van sedimentary profile since the end of MIS13. More interestingly, these two dolomites present high content (%) synchronously at the same sedimentary layers, which indicates there should be a close connection between their formation and origin. Scanning Electron Microscopy - Energy Dispersive Spectroscopy observation confirms the occurrence of dolomite that show multiple euhedral to subhedral crystal faces, and suggests the generally good preservation state of these dolomite minerals. Systematic clumped isotope (Δ47) analyses have been conducted on three dolomite samples (the other 20 samples are currently under analysis), and their calibrated temperature values by recently published unified calibration in Anderson et al. (2021) are 6 ± 3 °C (n=4), 6 ± 3 °C (n=4) and 21 ±3.5 °C (n=3), respectively, which are much lower than typical dolomite formation temperature.

Preservation of a river system imprint in the offshore detrital zircon record

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Depositional environments that are characterised by an interplay of marine and fluvial processes feature energy and sediment flux histories that are difficult to unravel. Glacioeustatically driven Holocene sea level rise led to dramatic shoreline retreat and extensive marine reworking of fluvial and coastal plain sediments globally. In southwest Australia, where the long-lived Swan River drains into the Indian Ocean, shoreline-parallel chains of islands on the shallow shelf attest to transgressive separation from the present-day mainland. We investigate thirteen carbonate–silicate sand samples collected from upstream tributaries of the Swan drainage within the Yilgarn Craton, the Swan River estuary, modern beaches, and wave- and tidal-influenced reefs on the seafloor offshore Rottnest Island. Detrital zircon U–Pb ages, α-dose values, and grain size information quantify movement, mixing, and relative contributions of different sources (tributaries, Swan Coastal Plain literature value) and the stability of sinks (estuary, offshore, beaches) in the Holocene. Tributary, estuary, and offshore samples contain three Archean Yilgarn-derived age groups that prevail over Mesoproterozoic and Cambro-Neoproterozoic components. Distinctive Paleoarchean zircon grains link to a specific tributary and trace flux into the estuary and offshore samples, which show near identical age distributions. Similar average α-dose values of the Paleoarchean zircon group underline the minimal modification of grains between tributary source and offshore sink. Furthermore, α-dose values in modern river samples capture chemical and physical degradation and downstream loss of metamict zircons within the Swan River estuary. Quantification via sediment mixing models indicates that the fluvial contribution to the detrital cargo in estuary and offshore samples is up to 50–65 %, whereas modern beach sediments are dominated by the coastal plain detrital components with subordinate Archean zircon U–Pb ages. Fundamentally, a distinct fluvial detrital signature is exceptionally preserved on the submerged continental margin despite several thousand years of marine inundation, high-energy reworking, and longshore drift.

Spatial Analysis of Ecological Impacts of Global Change on Dry lands And Their Implications for Desertification in Algeria

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Desertification is a crucial environmental problem in the Algerian steppe. Land degradation is a reduction and loss of land productivity due to natural processes, climate change and human activities. The sandy lands in the zone of Naâma constitute a region based on important pastures in west of Algeria. It is therefore increasingly necessary to monitor the situation to better understand the desertification processes and to fight against this phenomenon. Climate, soils, vegetation and land use play an important role in desertification. Therefore, the land surface temperature and a monitoring indicator that highlight the hottest areas as well as their delineation are important to characterize the phenomenon of desertification. In this study, we analyzed desertification since 2008 using remote sensing technology. In order to recognize desertification through land-use changes, our research was aimed at extracting classification categories representing the state of the land, which we subdivided into normal classification categories of vegetation groups. To this end, we have classified land use by combining several spectral indices in particular, which can be calculated from satellite data on each Land sat satellite spectral band, to construct multiband input data for a supervised classification approach based on a support vector (SVM). By applying this method to Land sat archival imagery in 2008, 2011, 2014 and 2017, we produced land use maps for the four periods. Using GIS, we integrated climatic parameters with rainfall and land surface temperature combined with land use land cover and slope, in this step; we adopted proposals from expert judgments to determine weights in order to assign weights to each parameter. This allowed us to clarify the situation with regard to desertification, to classify the study area in areas vulnerable to desertification and to determine the spatiotemporal changes during the 10 years.

How thin is a thin bed? Subsurface case studies of seismic-based, meter-scale fluvial architectural elements

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With modern three-dimensional seismic data, seismic sedimentology is a powerful tool for studying depositional elements and systems by pushing seismic imaging to a high spatial resolution (meaning horizontally resolved but vertically detected by seismic data). In the best-case scenario, a facies element as small as 1-m vertical and 15-m horizontal can be interpreted, which is comparable to outcrop resolution. While sedimentary facies can include many things, its essential part (lithofacies and geometry) can be addressed by seismic sedimentology through the integration of seismic lithology and seismic geomorphology. The useful techniques include using 90° seismic data, stratal slicing, frequency fusion, and machine learning (ML).

With sparse core and wireline-log calibration, seismic sedimentology workflow is especially effective in imaging thin and complex depositional facies architecture, such as in fluvial, deltaic, and deep-water systems. We will showcase the success by presenting two recent projects in fluvial architectural study aimed at predicting hydrocarbon reservoirs in prolific lacustrine basins. In one case study, nine 4-30 m thick fluvial architectural elements are recognized and mapped, including fluvial valley, floodplain, sand-filled and mud-filled channels, sand fan, lateral-accretion complex, sandbar, chute channel, incremental lateral accretion, and overbank. These elements were then assembled for various depositional styles in the meanderplain and braidplain. The workflow provides new strategies to improve mineral exploration, development, and reservoir modeling, which cannot be achieved by using sparse drilling data only.

Effect of the hydrothermal activity in the Lower Yangtze region on marine shale gas enrichment: A case study of Lower Cambrian and Upper Ordovician-Lower Silurian shales in Jiangye-1 well

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Finding favorable sites for the exploration of shale gas, is still one of the important areas of research that needs immediate attention. The content of organic matter in shale plays a crucial role in the hydrocarbon generation potential, reservoir space and gas-bearing capacity of shales. Therefore, studying the sedimentary environment of organic shale can provide a scientific basis for locating favorable exploration areas for shale gas. The article takes the Lower Cambrian and the Upper Ordovician-Lower Silurian shales in the Yangtze region as the research object and selects representative wells to quantitatively calculate the existence of excess silicon in shale siliceous minerals and the content of excess silicon. Then, the origin of excess silicon can be clarified by the Al, Fe and Mn elemental analysis. Finally, the sedimentary organic matter enrichment mechanism is analyzed from water oxidation-reduction environments and biological productivity. The results of the study show that the excess silicon in the Lower Cambrian and Upper Ordovician-Lower Silurian shales in the Lower Yangtze region is of hydrothermal origin. The hydrothermal activity improves biological fertility on the one hand; whereas on the other hand, it can enhance the reducing capacity of the bottom water conducive for the preservation of organic matter thereby enriching the sedimentary organic matter. The place near the junction of Yangtze plate and Cathaysian plate, where hydrothermal activities were more intense, provided favorable loci for shale gas exploration in the Lower Yangtze region. It was observed that, since the hydrothermal activity was stronger in the Early Cambrian than in the Late Ordovician-Early Silurian times, the total organic carbon (TOC) content of the Lower Cambrian shale was higher than that of the Upper Ordovician-Lower Silurian shales.

Fault-controlled reservoir modeling method based on multiple information fusion constraints ：A case study of tight sandstone reservoir in the southern margin of Ordos Basin

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The fault-controlled reservoirs within the tight sandstone exhibit complex properties and pronounced heterogeneity. Drawing upon core samples, well-logging data, seismic studies, dynamic information, and field observations, the internal structural characteristics of the fault-controlled reservoirs in the Chang 8 of the Yanchang Formation at the southern margin of the Ordos Basin are elucidated. Employing the methodology of "multiple geological causative constraints and multi-probabilistic fusion," a multifaceted information-constrained modeling approach is introduced. The findings reveal that these fault-controlled reservoirs are composed of a central fault core and surrounding associated damage zones. Vertically, they form a "grid-like structure" organized by the orderly arrangement of multiple sets of fault cores and damage zones. The porosity and permeability within the fault cores are significantly higher than the surrounding tight sandstone, rendering them excellent reservoirs. The damage zones play a crucial role in facilitating the migration of oil and gas. Fitting the relationship between conventional well logging and fracture density interpreted through imaging logging using a BP neural network enables single-well fracture interpretation, providing the essential "hard data" for the modeling process. Probabilistic fields characterizing the development of fault cores and damage zones are constructed separately based on prior geological causative factors and posterior seismic responses. Through the application of the PR probability fusion method, various probabilistic fields are integrated to serve as inter-well constraints. This, combined with the use of multipoint geological statistical Sneism algorithms, forms the foundation for establishing the fault-controlled reservoir model. The resulting model adeptly conbines the distribution and internal structural features of the fault-controlled reservoirs. Its numerical simulation results align closely with the dynamic production data from the oil field, making it a reliable basis for adjusting development strategies.

Paleoenvironmental evolution of the Gonjo Basin (Tibet) through the late Cretaceous to early Paleocene

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The hydroclimate of continental interiors is sensitive to anthropogenic carbon emissions and associated warming. The late Cretaceous to early Paleocene was characterized by a globally warm greenhouse climate, and may provide a useful analogue for understanding how hydroclimate responds to elevated atmospheric CO2 and temperature. However, a paucity of high-resolution and temporally well-constrained continental sedimentary records spanning this time interval hinders our understanding. We present new sedimentological and high-resolution XRF element abundance datasets from a 1305-m-thick fluvial succession spanning the late Cretaceous to early Paleocene from the Gonjo Basin (southeast Tibet). Principal component analysis (PCA) was conducted on the multivariate XRF element data to reduce the dimensionality of the datasets and obtain the major geochemical trends that reflect changing paleoenvironmental conditions through the section. Combined with a published magnetostratigraphy and a cyclostratigraphic analysis of our high-resolution geochemical data, we establish a high-resolution astronomical timescale spanning ~69.4 Ma to ~58.5 Ma. Using this timescale and the sedimentological and geochemical data, we reconstruct the paleoenvironmental evolution of the basin and reveal three stages of evolution: Stage 1 (~69.4-68.8 Ma): braided fluvial-dominated with relatively weak chemical weathering; Stage 2 (~68.8-63.5 Ma): floodplain-dominated with relatively strong chemical weathering; Stage 3 (~63.5-58.5 Ma), braided fluvial-dominated with relatively weak chemical weathering and a transient enhancement of chemical weathering during ~62.5-61.2 Ma. We assess the paleoenvironmental evolution of the basin in the context of global and regional climate changes through these stages, and we establish the role and mechanisms of orbital forcing as a driver of hydrological cycle change in East Asia at this time.

Reservoir Quality Distribution Model Based on Braided River Delta Sandbody Configuration: A Case Study of the Jurassic Ahe Formation in the Tarim Basin

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The northern part of the Kuqa Depression in the Tarim Basin has significant potential for tight gas resources in the Lower Jurassic Ahe Formation, making it an important area for natural gas exploration and production. Through the analysis of outcrop, core, thin section, and imaging logging data, the sand body configuration was accurately described, and the vertical construction, lateral distribution patterns, and reservoir properties of different lithofacies were analyzed. The reservoir characteristics and fracture generation periods were determined, and the control of sedimentation, diagenesis, and tectonic stress on the reservoir was discussed. Two main achievements were obtained: firstly, the Ahe Formation exhibits three types of sedimentary architecture, including large-scale gravelly braided channels-lateral accretion bars-longitudinal sand bars, medium-scale gravelly braided channels-transverse sand bars-lakefront composite sand bodies, and small-scale sandy braided channels-oblique sand bars. Secondly, the Ahe Formation is mainly composed of gray-white medium sandstone, coarse sandstone, and thin-layered conglomerate, with reservoir spaces mainly consisting of intragranular dissolution pores, fractures, micropores, and primary intergranular pores. The reservoir properties show significant variations in the plane. The Ahe Formation is mainly characterized by upright and high-angle shear fractures with low filling degree. Sedimentary processes primarily control the matrix properties of the Ahe Formation reservoir, with compaction being the main pore-reducing process and dissolution being the main pore-enlarging process. Paleotectonic compression stress has a dual effect of reducing permeability by pore reduction and increasing permeability by fracture generation, controlling the planar heterogeneity of the Ahe Formation reservoir characteristics. The study area consists of thick-layered (including gravel) coarse sandstone in a large braided river delta plain, and multi-scale and multi-genetic microfractures effectively connect micropores and intragranular dissolution pores in feldspar grains, facilitating the development of large-scale sweet spots in the reservoir and providing favorable exploration directions.

Research on the Formation and Pore Preservation Mechanism of the Cambrian Ultra-deep Dolomite Reservoir in the Tarim Basin

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The Cambrian ultra-deep dolomite reservoirs in the Tarim Basin have undergone multiple episodes of diagenetic fluids alteration, resulting in strong heterogeneity of the reservoirs. There is significant controversy regarding the dolomitization pathways and reservoir pore evolution processes of different facies of dolomite. It is believed that accurately identifying the key diagenetic events is crucial for understanding the reservoir pore evolution processes, which in turn affect reservoir evaluation and prediction. In this study, a quantitative analysis of the key diagenetic events in the Cambrian carbonate reservoirs of the Tarim Basin was conducted using a variety of techniques including core, thin section, cathodoluminescence, strontium isotopes, laser in-situ carbon and oxygen stable isotopes, laser in-situ U-Pb isotopic dating, laser in-situ elemental mapping, and imaging techniques. The results show that: (1) The reservoirs have experienced processes such as atmospheric fresh water dissolution, syn-sedimentary shallow burial dolomitization, and magnesium-rich hydrothermal fluid filling. Among these processes, early atmospheric fresh water dissolution is the main mechanism for reservoir formation in the carbonate platforms. (2) The distribution of saddle dolomite and siliceous fillings is controlled by deep faults and permeable layers, further enhancing the heterogeneity of the reservoirs. The main pore bodies in the existing dolomite reservoirs are inherited from pre-existing pores, with residual cavities and fractures constituting the main reservoir spaces. Fracture-hydrothermal alteration plays an important role in reservoir adjustment, rather than the traditional concept of tectonic-hydrothermal dissolution for pore formation. These findings provide a basis for the study of pore genesis in deep-ultra-deep carbonate reservoirs and effective reservoir prediction in the Tarim Basin and other similar areas.

Main controlling factors and distribution of high quality reservoirs of deep buried dolomite in typical craton basins in China

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Deep dolomite in craton basin is an important field for future natural gas exploration in China. Through statistical analysis， it is clear that the main types of deep dolomite are granular dolomite， microbial dolomite and crystalline dolomite， the pore types are mainly fractured fissure cavity and fractured pore type. It is pointed out that favorable sedimentary microfacies are the material basis for pore formation， early dissolution is a necessary condition for pore formation, dolomitization is beneficial to preservation of early pores， epigenetic karstification and structural fracture improve reservoir property. Definite， the deep quality dolomite reservoirs are still facies controlled， the deep dolomite reservoir is more inherited than transformed， the vertical distribution is not controlled by depth， but controlled by early sedimentary cycles， the lateral distribution is not controlled by karstification， but controlled by high-energy sedimentary facies belts. It is considered that the exploration of deep quality dolomite reservoirs in the future will be mainly “both sides of the inner rift of platform" and carbonate ramps.

Origin of cryptocrystalline aragonite in Oligocene lacustrine black shale, Bohai Bay Basin

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Inorganic aragonite is commonly found in various depositional environments, and its precipitation is influenced by complex physio-chemical factors. This study investigates the diagenetic conditions that led to aragonite precipitation in Oligocene lacustrine black shale of Bonan Sag, Bohai Bay Basin. A total of 35 samples of black shale hosting cryptocrystalline yellow aragonite were collected from the BS8 Well within the first member of Shahejie Formation. Microscopic examination, SEM observation, and LA-ICP-MS analysis reveal the presence of laminae consisting of cryptocrystalline aragonite within the black shale. Cryptocrystalline yellow aragonite is commonly observed as authigenic seep carbonates forming near the sediment-water interface today. The occurrence of light rare earth element (REE) enrichment in yellow aragonite, along with high organic matter contents indicated by intense autofluorescence and low Mg/Sr ratios, suggests primary signatures and pore fluid diagenesis within a predominantly closed system. Furthermore, biofilm-influenced pore fluids resulted in LREE enrichment during aragonite precipitation. The significantly positive δ13C values for cryptocrystalline aragonite (δ13C = 6 to 7.5‰ Vienna PeeDee Belemnite) and dolomite (δ13C = 12 to 18‰ Vienna PeeDee Belemnite) provide evidence for authigenic precipitation within methanogenic lake sediments. Micron-sized spheroidal bodies are interpreted as mineralized coccoid methanogenic archaea, while the knobby appearance on the surfaces of aragonite crystals confirms that extracellular polymeric substances (EPSs) influence their precipitation process. Combining geochemical and microscale evidence confirms that methanogens and their associated bacteriophages play a significant role in influencing aragonite precipitation. These findings provide valuable insights into deciphering biosignatures associated with specific types of aragonites found in black shales.

Petrographic types and reservoir characteristics of fine-grained sedimentary rocks in saline lacustrine basin: A case study of the Xiaoliangshan Depression in Chaixi, Qaidam Basin, China

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The Xiaoliangshan Depression in the western Qaidam Basin (Chaixi Area) is about 800km2, where develops fine-grained sedimentary rocks of saline lacustrine in the Neogene Upper Ganchaigou Formation (N1). Combined with the data of outcrop, drilling, core and element geochemistry, the lithofacies type, depositional environment, evolution sequence and reservoir characteristics are studied in N1, and three research insights are obtained. Firstly, it is determined that N1 develops 7 lithofacies types mainly, including algal limestone, laminated lime-dolomitic shale, laminated dolo-calcitic shale, thin-laminated calcitic dolostone, thin-laminated dolomitic limestone, thin-laminated silty mudstone, and thin-laminated calcitic siltstone, and the vertical single-cycle sedimentary sequence model is established. It is pointed out that the five carbonate facies developed in the semi-cycle of decreasing lake level with increasing evaporation intensity, increasing water salinity and shallower water depth. Secondly, it is clear that the reservoir types of fine-grained sedimentary rocks are mainly dissolved pore type and intercrystalline pore type, and the favorable reservoirs are related to lithofacies type, argillaceous content and dolomite content, among which the quality of carbonate reservoir is better than that of felsic/clayey reservoir, and that of thin-laminated calcitic dolostone is better than that of laminated lime-dolomitic shale. The shale content is negatively correlated with the reservoir properties. The shale content of laminated lime-dolomitic shale is higher than that of thin-laminated calcitic dolostone, and the reservoir properties become worse. The dolomite content is positively correlated with reservoir properties. Dolomite is formed in saline evaporation environment, and the dolomite content decreases with increasing terrigenous detritus recharge. Thirdly, it is revealed that the fine-grained sedimentary rocks sweets have the characteristics of "double high" lithofacies associations of the laminated lime-dolomitic shale with relatively high organic carbon (0.4-1.3%) and the thin-laminated calcitic dolostone with relatively high porosity (5-10%), and the two lithofacies are interbedded at high frequency vertically.

Study on the Sedimentary Characteristics and Reservoirs of Sand-gravel Bodies of Es3 – Es4 of Northern Bonan Depression

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The subaqueous coarse clastic rock fans in the Northern Bonan Depression of the Bohai Bay Basin are one of the typical reservoirs for oil and gas accumulation in the Mesozoic-Cenozoic continental rift basin. With the comprehensive exploration of oil and gas fields in eastern China transitioning from the concealed exploration phase to the refined exploration phase, the lack of understanding of the internal structure and distribution law of favorable zones within the subaqueous coarse clastic rock bodies has seriously hindered the exploration and development of such oil and gas reservoirs. This paper focuses on the subaqueous coarse clastic rocks of the third member - fourth member of the Shahejie Formation （Es3–Es4） of Northern Bonan Depression as the research objects. By integrating seismic, logging, core, and analysis tests, investigating the genetic types, sedimentary structures, and transport processes of subaqueous coarse clastic rocks under differential tectonic activities. Furthermore, a comparative analysis of reservoir characteristics and the main controlling factors for reservoir properties are carried out for different types of subaqueous coarse clastic rock bodies, aiming to provide a clear understanding of the development mechanisms of high-quality reservoirs. The following understandings have been obtained.
A sedimentary evolution sequence of subaqueous coarse clastic rocks controlled by differential tectonic activity is proposed. In Es4, the segments of the boundary faults experience a low tectonic subsidence rate, relatively gentle topography, and sufficient sediment supply, fan deltas form. The subaqueous distributary channels cut each other, migrate and swing frequently, resulting in a wide lateral distribution of the fans.In Es3,the segments of the boundary faults experience high tectonic subsidence rates and large drops, which contribute to the development of nearshore subaqueous fans. The internal migration and superposition of multi-stage fan bodies occur, while the lateral migration capacity of braided channels is weak, and vertical accretion dominates the overall deposition.

Architecture of a migrating channel belt: insights from the slope channel-levee Complex 6 (Tachrift turbidite system, Tortonian, NE Morocco)

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Characterization of turbidite channel-levee deposits in ancient strata is significant in subsurface modelling of deep-water systems, where data are restricted to narrow borehole sections or seismic images. We present Complex 6, one of multiple turbidite channel-levee complexes making the Tachrift system (Late Tortonian-early Messinian), exceptionally exposed in NE Morocco as part of the clastic fill of Taza-Guercif Basin. Goal is to document its 3D architecture, facies assemblages, and evolution, to be integrated with the ongoing surveys of the basin fill. The method integrates geological mapping, facies analysis on 46 logs, and 3D physical stratigraphic correlations. Statistical analyses on sedimentological variables supported quantitative comparison among depositional elements and their lateral transitions.

Complex 6, 13 m thick, consists of three sandstone-rich units, A, B, and C, that progressively increase in grain-size and are laterally stacked in a SE-ward shifting fashion. The tabular, fining-upwards sandy packages with rare concave-upwards erosional surfaces in unit A suggest a system of small sinuous and ephemeral distributary channels. Upwards, unit B and C display channel-fill deposits and genetically linked levees with different crossflow facies tracts, that record changes in flow parameters and morpho-dynamics of the parent channel. Unit B shows deposition in sinuous meandering channels, dominated by LAPs that make transition to levees at the accreting inner bank, showing complex lateral relationship with the outer bank levee; unit C is characterized by relatively straighter channels where amalgamated sandstones (i.e., channel axis) laterally pass into sandy levee crests, then to mud-prone outer levee heterolithics. 3D stratigraphic architecture of complex 6 reveals an eastward channel belt migration and a progressive flow energy/density increase. Owing to magnificent 3D exposures, the study provides sedimentological characterization of channel-levee transitions, insights into evolution of their parent channel from inception trough abandonment and predisposes sub-seismic lithological calibration of subsurface analogues.

Pre-salt Carbonate Reservoir Prediction and Fluid Identification Techniques and Applications in Santos Basin

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This article focuses on the issues of reservoir and hydrocarbon prediction in the pre-salt petroleum exploration of Santos Basin, includes three aspects: (1) Facies controlled carbonate reservoir prediction technology guided by integrated geological models. Based on the study of structural characteristics, such as amplitude, waveform, and curvature, seismic facies research is conducted. Reservoirs show different energy in different frequency, thus it is further enhanced through the use of highlight attribute analysis technology to characterize reservoirs. Under the constraints of geological laws of seismic and sedimentary facies, innovative facies controlled inversion ideas are proposed to achieve reservoir quantitative prediction. (2) Innovative volcanic organization guided igneous rock seismic identification technology. By using seismic forward modeling to reveal the seismic feature, such as velocity, impedance and other characteristics of intrusive rocks, a "strong amplitude+low frequency+high impedance" method is established to achieve prediction of intrusive rocks. By analyzing the patterns of underwater volcanic eruptions and establishing a volcanic mechanism model, the distribution of eruptive rocks can be predicted through multiple attributes such as coherence, amplitude, and seismic facies characteristics. (3) Integrated seismic identification technology for carbonate reservoir fluids. By integrating frequency amplitude and attenuation gradient for hydrocarbon detection, the oil layer shows "low-frequency resonance, high-frequency attenuation, and fast attenuation gradient" feature. Based on forward modeling and fluid replacement, optimize AVO sensitive rock physical parameters to predict reservoir fluid types and distribution. Dual parameter intersection and fluid probability inversion is used to predict fluid types and distribution.
Through this research, the accuracy of reservoir prediction has been improved from 60% to 85%, with a coincidence rate of 100% for intrusive rocks and 84% for eruptive rocks. This technology series has solved the main problem that restricts efficient exploration in pre-salt of Santos basin, effectively supporting and promoting the rapid exploration in Block Libra and Aram.

Sediment characteristics and benthic foraminifera distribution in specific shallow marine environment of Northern Adriatic

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The predominantly siliciclastic sedimentation along the Slovenian coast reflects the geological composition of hinterland and is influenced by the resuspension by waves, currents and suspension flows as well as production of biogenic carbonates. Sediment characteristics changes depending on the conditions at certain micro location, which is reflected on grain size, mineralogy, geochemistry, organic matter, and benthic communities. In this study, the marine sediments around submarine sulfur rich springs near Izola were investigated.

In funnel shaped depressions (pockmarks), known as Žumer's Hollows, warm (measured up to 31.2ºC) and sulfur rich water appears. Depressions occur in the Quaternary sediment up to 11 m deep below the sea-bottom, which in turn has a depth of 16.5 to 22.5 m. The water erupts with varying intensity and at irregular intervals, destabilizing the sediments and organisms living there. The plastic core tubes were inserted into the sediments near the springs at the bottom of depressions.

Predominately sandy silt sediment of the area is partly washed directly at the springs. Gravel-sized particles represent biogenic debris. Sediment characteristics indicate also different types of sediment origin which is associated with the depth of depressions. Shallower depressions are formed entirely in the marine sediments, while deeper depression cut deeper into pre-transgression continental sediments with alluvial characteristics. Foraminiferal shells (benthic foraminifera) contribute a lot to the sediments. Comparison with the nearby areas of the northern Adriatic shows that the foraminiferal density is many times lower, while the number of species and evenness are similar. Along the sediment cores, the effect of time-averaging is not evident, indicating mixing of the sediments during the spring outflow.

Significance and Impact of Injection Breccia in Sand Injection Complexes

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Injection breccia is a significant component of sand injection complexes; however, its occurrence is often unreported, and its origin and significance misunderstood . In core and outcrop, injection breccia is frequently interpreted as having a depositional origin, for example, debrite facies including hybrid beds. Inability to differentiate these facies leads to different facies associations interpretations, which in turn produce vastly different models of the sedimentary evolution of basins.

Because the lithologies are predominantly mudstone clast rich with a sandstone matrix, they have superficial similarity. However, their relationship to adjacent strata is entirely different. a) Debrite/hybrid beds are mostly bedding-parallel and laterally extensive (km-scale) as part of depositional systems that record periods of regionally developed depositional processes. By contrast, b) injection breccia is commonly laterally discontinuing and discordant to bedding, in association with other sand injectite facies (dykes, sills, wings).

Outcrop data from the Tumey Giant Injection Complex showcases injection breccia facies associated with deep water turbiditic succession, forming irregular and discontinuous breccia zones mainly discordant to bedding of matrix- to clast support breccia, reaching >80 m thickness and extend 100’s metres laterally. They develop best, (1) adjacent to parent units, (2) in association with sandstone intrusions, and (3) in thick sections of biosiliceous mudstone.

Sand injection and brecciation occur during periods when large volumes of fluid flow focus in parts of the shallow crust and form extensive hydrofractures, some of which become sand filled and create regionally developed (sometimes >10,000 km2) sand injection complexes. Injection breccia causes significant modification of subsurface drainage patterns and huge changes in the transmissivity of sedimentary basins. Failure to differentiate these contrasting strata may confuse depositional processes with catastrophic shallow crustal deformation and in subsurface studies has major effect on uncertainty regarding resource extraction and CSS risks.

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