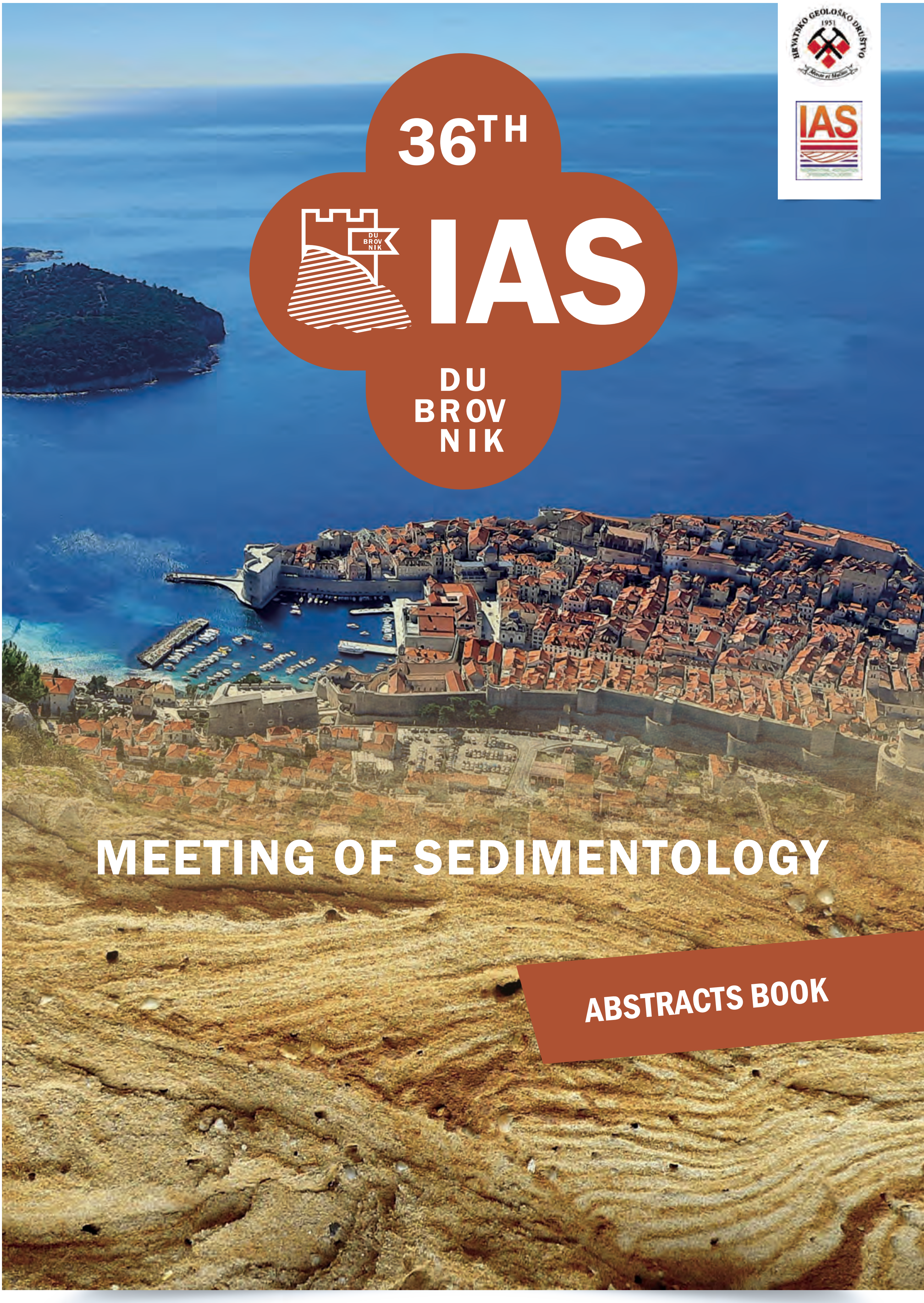

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ABSTRACTS BOOK

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Plenary Lecture

Coastal Changes in the 21st century: Perspectives from a sedimentologist

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The majority of global coasts are projected to experience sea-level rise in the 21st century. Coasts and coastal lowlands are of great societal, economical and agricultural value with nearly 40% of the World's population living within 100 km of the coast. Understanding the causes of coastal change is urgently needed to mitigate risks, prepare, and adapt to acceleration of sea-level rise and more severe and frequent extreme weather events in the 21st century.

As reflected in the reports from the Intergovernmental Panel on Climate Change (IPCC), most research effort in predicting global-scale coastal changes in this century is focused on global sea-level changes, including the effects of melting ice-sheets and glaciers, the contribution from thermal expansion of oceanic waters, oceanic and atmospheric circulation, glacioisostatic adjustments (GIA) and gravitational effects. Thus far, less emphasis has been on fully integrating the impacts of global sea-level changes with the key natural and anthropogenic forced processes of vertical land movements, sediment delivery and sediment distribution, factors which are critical to understand and predict coastal changes.

In this talk I will review the key factors determining coastal change and the current status of coastal change predictions for the 21st century. I will also address the relationship between coastal type and present and future population density and inundation levels.

Plenary Lecture

Past climate changes – a view from the karst underground

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Climate change is one of the greatest challenges that the human society is facing nowadays. The 30-year long history of addressing this issue by scientific community might imply that palaeoclimate research is losing its relevance in the 21st century. Yet, an increasing number of high-quality research studies performed around the world would argue against this and witnesses the importance of palaeoclimatology as a backbone in understanding not only the causes of the natural climate variability in the past but also in assisting more accurate predictions of anthropogenically-driven climate changes in the future.

Speleothems, secondary cave deposits like stalagmites and flowstones, play an outstanding role in the field of palaeoclimatology firstly due to their amenability to radiometric dating as well as due to the possession of a remarkable number of climate-sensitive proxies. The majority of studies on past climate changes derived from speleothems rely on U/Th disequilibrium dating method. In this talk I will demonstrate an example where the less widely used U/Pb dating method for dating of speleothems has enabled deciphering one of the longest standing palaeoclimate debates centered around the causes of glacial–interglacial transitions, specifically during the Middle Pleistocene transition.

Despite their indisputable strengths, speleothems are not free of weaknesses like any other palaeoclimate archive. One of their most significant weaknesses lies in the often complex and skewed link between their chemical proxies (e.g. stable isotope ratios of oxygen and carbon, trace element composition) and climate variables at the surface. It was long time ago understood that extensive cave monitoring studies might help in resolving this conundrum by exploring the processes involved in transferring and modifying the climate signal from the surface, through the soil zone, epikarst and bedrock to the cave interior and finally speleothems under modern conditions. In the last part of this talk I will present results of a recently started project that includes a monitoring program of a cave site in North Croatia and their implications for interpretation of speleothem records from this site and beyond.

Plenary Lecture

Not all is lost. How we study mudstones on Mars without thin sections and make a virtue of necessity.

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As on Earth, mudstones are likely the most abundant sedimentary rock on Mars and a key component in our efforts to search for life on other planets. In the quest to understand a mudstone's origins, the study of thin sections traditionally represents the coin of the realm. Yet, whereas on Earth this may not always be easy, but doable nonetheless, on Mars – it is not even an option. Mars rovers may return images at a range of resolutions (20–200 microns per pixel), but even at best resolutions they are a poor substitute for something as simple as a 10x hand lens.

Fortunately, mudstones have a live beyond the microscopic. Especially in the absence of bioturbation (a sensation were we to find it on Mars), mudstones display textural, compositional, and bedding attributes that are accessible to rover instrumentation. Whereas on Mars we do not have the benefit of saw-cut and polished slabs to make these features optimally observable, we do have "lucky breaks" where the soft touch of millennia of Aeolian abrasion brings out highly instructive details of texture and bedding that can be captured by on-board cameras. Also, in the case of Mars Science Lab (MSL), allied instruments like APXS (bulk rock composition), ChemCam (remote chemistry via Laser Breakdown Spectroscopy), and CheMin (mineralogy by XRD) provide us with bulk chemical and mineral composition, and even grain by grain chemistry.

Through carefully considered integration, comparison to Earth analogs, and qualitative and numerical modeling, these data sets provide a compositional and textural context that can provide insights into depositional conditions and diagenetic history that are just as profound as those obtained through traditional petrographic approaches. Though necessitated by limitations in resources, the way we study mudstones on Mars brings with it new and different perspectives that also provide untrodden pathways for their study on Earth. To paraphrase T.S. Eliot; the limitations of rover geology shall not keep us from studying Martian mudstones, and at the end of the journey we will conceptually arrive where we started, and know those we thought we knew for the first time.

Theme 1. Continental carbonates, karst and cave deposits

Special Session 1.1. The response of continental carbonates to (paleo)environmental perturbations: new insights from emergent and old/refined indicators

Oral presentation

Agricultural irrigation systems in volcanic islands: carbonate factories in continental settings

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Human perturbation in continental settings may drive not only modification of sedimentary regimes of continental carbonates, but also create new depositional environments for carbonate system. This is the case of Lomo Morin tufa in Tenerife, where the use of irrigation water has modified the hydrogeological system. The water is obtained from galleries excavated in the volcanic rocks. A 930 m long channel drives the water to the slope causing it to splay over a wide area, including five waterfalls. The water is collected downslope and used for irrigation of banana plantations. The tufa forms in the slope and cascades. It is about 200 m long and 50 m wide, elongated in a S–N direction. The visible height of the carbonate deposit is about 90 m. Geo-biological interactions occurring in the Lomo Morin tufa are similar to those of natural tufa systems, although they differ in terms of the greater speed at which they occur in the anthropogenic tufa, the smaller variation in its facies and microfacies, and its rapid diagenetic activity. At the macroscale, the existence of fresh water on the slope allows for the presence of the green macroalga *Blidingia*. This generates an unusual damp, green environment in which boundstones of green algae and coated stems, laminated clumped crusts and reworked tufa debris are seen. The metabolism of algae and cyanobacteria, their organic matrices, and mechanical agitation exert an influence over crystal morphologies. Rapid oversaturation led to disequilibrium and fast fibrous-radial calcite growth, while lesser saturation levels favoured larger, more equidimensional crystals. Carbon and oxygen isotope values (-0.56‰ V-PDB and -6.11‰ V-PDB respectively) indicate the meteoric origin of the water, with some addition of deep sourced CO_2. The $^{87}Sr/^{86}Sr$ ratios, 0.703010 to 0.703051 are similar to those of the nearby volcanic rocks, indicating also the source of calcium. The Lomo Morin tufa provides a scale model of how water use contributes to rapid landscape change through alteration in the hydrogeological system, and provides a good example of a CO_2 sink in a continental setting. Although anthropogenic-related process are commonly viewed negatively, here they caused changes in the geological and ecological conditions that have increased both the geo- and bio-diversity of the island.

Theme 1. Continental carbonates, karst and cave deposits

Special Session 1.1. The response of continental carbonates to (paleo)environmental perturbations: new insights from emergent and old/refined indicators

Oral presentation

The temporal variability of the Holocene calcium carbonate deposition at four alkaline fens in the young glacial area of central Europe

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In the present study, we aim to determine the factors responsible for the temporal variability of $CaCO_3$ (tufa) deposition at four alkaline fens located in north-eastern Poland and Latvia, within the extent of the Weichselian glaciation: Turtul (Tu), Puszcza Romincka (PR), Maitiku (Mai), and Lustūžkalns (Lus). To complete the aim we recognised the palaeoenvironmental history of the fens by applying plant macrofossil, mollusc, loss on ignition, and $\delta^{13}C$ and $\delta^{18}O$, analyses in two sediment sequences, taken from the top and slope of the fen mound, at each of the sites. The chronology of the sediments is based on radiocarbon dates from plant macrofossils. The time frames of $CaCO_3$ accumulation varied between the fens. In north-eastern Poland, tufa was deposited between ca. 11650 and 50 cal yr BP at PR and between ca. 9250 and 5400 cal yr BP at Tu. The early Holocene onset of $CaCO_3$ accumulation was associated with the activation of groundwater circulation following permafrost degradation. The decline in tufa deposition ca. 5400 cal yr BP in Tu can be related to climate cooling in the mid-Holocene. The cooling affected not only the conditions of tufa precipitation but also indirectly decreased the rate of Ca^{2+} supply controlled by chemical denudation of the scattered $CaCO_3$ from glacial sediments in the aquifer. Also, after leaching during the early Holocene, this carbonate reservoir became a gradually less efficient Ca^{2+} source. The Holocene-long tufa deposition at PR fen, exceptional in north-eastern Poland, likely resulted from site-specific hydrogeological conditions assuring an efficient supply of Ca^{2+}-rich artesian waters. At Mai and Lus, enhanced tufa accumulation has been observed only since ca. 3500–3200 cal yr BP, when the increased climate humidity resulted in higher water levels at bogs and fens in Latvia. The Palaeozoic limestone bedrock, an inexhaustible source of Ca^{2+} ions, assures intensive tufa deposition at those sites. The high temporal variability of tufa deposition at the four investigated alkaline fens can be attributed to the complexity of factors controlling tufa deposition, with the largest influence of such factors being local climate fluctuations, type and richness of Ca^{2+} source, and hydrogeological conditions.

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Theme 1. Continental carbonates, karst and cave deposits

Special Session 1.1. The response of continental carbonates to (paleo)environmental perturbations: new insights from emergent and old/refined indicators

Oral presentation

Proterozoic dolostones deposited in an ice-covered, alkaline lake during the Sturtian panglaciation

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After the Boring Billion – a long period of apparent stability in Earth's oceans and atmosphere spanning the middle Proterozoic, the Earth experienced the most widespread and long-lasting glaciation. The Sturtian glaciation began synchronously on all continents during the Cryogenian (~720 Ma). It is still debated whether Earth was a totally ice-covered Snowball or a "Slushball" with ice-free regions in the equatorial oceans. Here we provide the first report of syn-glacial, lacustrine sedimentary rocks radiometrically dated to 710 Ma, coeval to the Sturtian glaciation. The dolostone-rich Lapichi Fm. from Belarus developed on older siliciclastic sediments covering the Great Unconformity of the Baltica paleocontinent. Our goal was to constrain the paleoclimatic conditions and the extent of ice cover on Baltica during this extreme period. The dolostones are dominated by primary, stoichiometric dolomite associated with microcrystalline magnesite, artinite, pseudomorphs after aragonite and possibly ikaite. Massive, brecciated, and laminated facies are distinguished, the latter linked with coccoid cyanobacterial structures. Radiogenic Sr isotope composition and lack of fabrics typical for Proterozoic marine carbonates support our interpretation of a non-marine paleoenvironment. The strong $\delta^{13}C$–$\delta^{18}O$ covariance suggests a closed basin. Dropstone-rich rhythmite facies, ikaite and clumped isotope data (dolomite paleotemperature = 10–18°C; $\delta^{18}O$ of parent fluid = ca. -10‰) point to cold climate and meteoric water source. We propose that the Lapichi dolostones formed by precipitation of Mg-rich carbonates in a closed, ice-covered, cold-water, hypersaline, highly alkaline, Mg-rich lake, with cyanobacteria-dominated mats colonizing the lake floor and mediating carbonate precipitation. Given the paleoclimatic conditions and sedimentological features we think that the lake was located in a dry oasis, analogous to the modern lakes in the Antarctic Dry Valleys. Our work shows that the continental part of the Earth was incompletely glaciated during the Sturtian glaciation. Furthermore, the rocks, paleoenvironment, and microbial structures here reported might represent potential analogs of early Martian lakes.

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Keynote lecture

The ostracod clumped-isotope thermometer: a novel tool to reconstruct quantitative continental climate changes

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In many modern and ancient lakes, ostracod shells constitute the only carbonates capable to record climatic and environmental changes at high-resolution. Ostracods are small aquatic crustaceans (mostly 0.3–5 mm) with a stable low-Mg calcite shell mineralogy, which makes them ideally suited for targeted geochemical analyses. Therefore, ostracods represent the best candidate to develop a new carbonate clumped isotope (Δ_{47}) lacustrine paleothermometer able to disentangle the effects of global climate changes at regional scale. The relationship between Δ_{47} and the temperature at which ostracod shell crystallized, is determined by measuring Δ_{47} on different species grown under controlled temperatures in both natural environments (4 ± 2°C; 12 ± 1°C) and lab cultures (23 ± 0.5°C). Clumped analyses were performed at the Vrije Universiteit Brussel (AMGC-VUB lab) using a Nu Instruments Perspective-IS stable isotope ratio mass spectrometer in conjunction with a Nu-Carb carbonate sample preparation system. The strong agreement between ostracod data and previous published calibrations demonstrate that clumped-isotopes technique can be applied to ostracod shells. No consistent offset between the two species originating from the same environment and precipitated at the same temperature is reported, suggesting the absence of a vital effect in ostracod Δ_{47}. A first application made on a record from the shallow Lake Trasimeno (Italy), that cover the last ca. 50,000 years, allowed to identify warmer/colder and humid/dryer conditions during Greenland Interstadial and Greenland Stadial, respectively. The ostracod-Δ_{47} thermometer constitutes a reliable tool for continental palaeoclimate reconstructions. It can be applied to all ostracod species, facilitating the recovery of the required carbonate amount, and can be widely used in freshwater systems in all climatic belts.

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Oral presentation

Precipitation mechanisms and early diagenesis of modern cryogenic cave carbonates

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Snežna jama (1556 m a.s.l., N Slovenia) is an alpine cave formed in Triassic limestone and dolostone. It contains a variety of cave deposits including fluvial sediments, classical calcite speleothems, moonmilk and dolomite speleothems. During the winter, fine cryogenic cave carbonates (CCC_{fine}) are precipitating on the surface of ice stalagmites, stalactites, and an ice lake near the cave entrance. These speleothems are loose mineral accumulations that form by the segregation of solutes during the freezing of calcium bicarbonate solutions, but can also be affected by degassing and evaporation processes and by the melting of the ice in late spring. To evaluate the relative influence of all these processes on the genesis and mineralogical evolution of CCC_{fine} we have monitored the cave environmental conditions and performed petrographic and geochemical analysis of samples collected and examined under both cryogenic and room temperature conditions.

The studied CCC_{fine} consist of detached flakes similar to cave rafts, 50 to 200 µm in diameter and around 20 µm thick, composed of calcite, aragonite and lansfordite ($MgCO_3 \cdot 5H_2O$). They display a wide variety of crystal habits, from different types of rhombohedral calcite, to needle-like aragonite and tabular or hexagonal lansfordite crystals with desiccation cracks. Observation of frozen CCC_{fine} samples on ice fragments using adapted CryoSEM techniques revealed textures possibly corresponding to metastable carbonates such as amorphous calcium carbonate (ACC), vaterite and ikaite. Coexistence of vaterite-like spheres with small rhombohedral crystals in lab-melted samples suggests that $CaCO_3$ initially precipitates as metastable vaterite and then rapidly transforms into calcite in the presence of liquid water. CCC_{fine} from Snežna jama show $\delta^{18}O$ values ranging from -4.34‰ to -6.24‰ VPDB and a wide range of $\delta^{13}C$ values (from 0.34‰ to 6.81‰ VPDB) which probably reflect variable influence of freezing versus CO_2 degassing processes in mineral precipitation, or different extent of diagenesis. These findings demonstrate the complexity of processes affecting the mineralogy and chemistry of carbonates in cold cave environments, where the primary features can be strongly affected by very early post-depositional mineral transformations.

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Oral presentation

On the origin of coloured patinas over speleothems in a Mediterranean cave

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Inactive-growing speleothems of calcium carbonate in caves are often coated by superficial patinas which show different characteristics and whose origin can be also diverse, related to a variety of physical, chemical, biological, and anthropological causes. The characterization of those patinas and their relation to genetic processes in present-day cave conditions can contribute to understand alteration processes affecting speleothems, and to advance in topics that range from paleoenvironmental reconstructions (e.g., "fossil" patinas) to present-day preservation tasks in caves. In this work we study different patinas found in Don Juan Cave (Valencia, Spain) in order to infer their origin and possible relation to cave microclimate. Don Juan is a touristic cave located 75 km away from the Mediterranean Sea. The cave preserves remains of prehistoric occupations and an exceptional speleogenetic heritage. It is developed in a Neogene unit that consists of heterogenous carbonate breccias. We defined four types of patinas according to their colour and aspect inside the cave. We named them as black, reddish-black, grey and whitish patinas. Black patinas occur mostly in areas with current bat activity, reddish-black patinas are dominant in areas without dripping and with limited external microclimatic influence. Whitish patinas are not as frequent as the others and are also localized in the same area than the reddish ones. Finally, grey patinas dominate in the humid zone, an area with permanent dripping and isolated from the outer temperature. All these patinas appear covering speleothems, soils and some walls. However, they do not occur on the ceilings. We studied these patinas under transmitted light microscopy, fluorescence microscopy, scanning electron microscopy, X-ray diffraction and infrared spectroscopy. The obtained results allow us to identify variable amounts of calcium phosphate, organic matter, gypsum, iron oxides, clays and microorganisms. The presence of organic matter, phosphates and gypsum in most of the patinas suggests that their origin can be related to bat guano. Final mineralogic proportions should depend on the distance to the source area, the time passed and the specific microclimate of the area. This study adds new information about the mineralogical richness and evolution in Don Juan Cave.

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Oral presentation

Investigating the intermittent carbonate factory of the mid-Miocene Eger Rift Basin in Central Europe: a geochemical approach

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We examine the paleoenvironmental significance of an iron-rich marlstone (M1) facies that disrupts the otherwise monotonous, argillaceous, tuffaceous and organic-rich sedimentary infill of the continental Eger Rift Basin (subsurface of the Karlovy Vary and Ústí na Labem regions, NW Czech Republic). Between ~17.5 and 16.9 million years ago, a wetland was transitioning to a system of paleolakes. The M1 facies recorded details of this transition, and upon it first appearance, at the base of the studied succession, it included pedogenic siderite concretions associated with wood material. Later, during the mid-Miocene (16.9 to 14.7 Ma), a relatively less organic-rich, fine-grained siliciclastic succession accumulated in two sub-basins, the Cheb–Sokolov and Most. The rock record in these sub-basins consist predominantly of a claystone lithology containing low maturity, mixed type I and II kerogens. The claystone is punctuated by M1 which contains ferroan dolomite and/or siderite abundances. These carbonates are nano- to micro-crystalline cements that mark the development of ephemeral, schizohaline, redox stratified, and sustained alkaline lake stages. Benthic microbial carbon respiration at times when M1 occurred was governed by iron reducers and methanogens, whose metabolic pathways left characteristic stable C isotope signatures in their carbonate by-products ($\delta^{13}C$ values range = [-10.2, +19.3 ‰], mean = +1.0 ± 6.3, n = 102). Results from bulk-rock stable $\delta^{15}N$ values also show transient excursions of about 2 ‰ from the inferred water-column-buffered, base-line signal (~9 ‰), pointing to anoxic periods that enhanced ammonia release from sediments. Our results support a dynamic paleoecology in which the lake trophic balances were significantly impacted by recurrent climate forcings.

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Oral presentation

Linking product and process in terrestrial carbonates: experimental construction of a robust phase diagram

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Terrestrial carbonate systems have a very diverse range of deposit characteristics, from variable mineralogy to variable microfabrics. Generally, it is presumed that the changes in fabric reflect changes in depositional conditions. The extraordinary morphological diversity, from single crystal rhombohedral prisms, to spherulitic to dendritic aggregates and the various driving forces behind crystallisation make linking process and product a challenge. Despite many decades of thorough descriptive and interpretative work on these fabrics, we are still only in a position to qualitatively link process and product, and subjective interpretation is still a key tool in our science. Calcite morphogenesis results from the complex interaction between different driving forces, (e.g., carbonate mineral supersaturation, Mg/Ca ratio of the parental fluid, organic and inorganic additives) which can act simultaneously or competitively to influence product properties. Here, we show that we can experimentally address the sedimentological causes of calcite morphogenesis using an experimental approach. This has produced a first calcite growth-form phase diagram, which can be used in the manner of bedform diagrams in clastic sedimentology. Although the approach should be transferrable to any chemical or microbial carbonate setting, the aim of this initial study was to account for the carbonate products experimentally nucleated in alkaline, saline lakes. The key driving forces for these settings are the calcite supersaturation level of the parental fluid, and the concentration of microbial-derived organic molecules (alginic acid). Together, these influences dominate final calcite crystal morphology and thus sediment fabric. We find common naturally-occurring calcite products such as calcite floating rafts, rhombohedral prismatic forms, di-pyramid calcite crystals, spherulitic calcite grains, or vertically stacked spheroidal calcite aggregates, can be related to specific hydrogeochemical contexts. We predict that exploring binary or ternary responses to forcing in morphological phase-space will allow a wide range of microbial and chemical carbonate sediment fabrics to be objectively related to environmental conditions in a quantitative and reproducible manner.

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Oral presentation

Using Electron Backscatter Diffraction (EBSD) to reveal formative mechanisms of Cretaceous lacustrine stromatolite at ultra-high-resolution

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Well-preserved lacustrine stromatolites in the Cretaceous Banyawol Formation (southeastern Korea) are characterized by decimetre-scale mounds with micro- to millimetre-thick alternations of micritic and crystalline layers. We applied combined Electron Backscatter Diffraction (EBSD) and Energy-dispersive X-ray spectroscopy (EDS) to understand the formative processes of these stromatolites at ultra-high-resolution. There are two types of micritic layers (100–500 µm thick), both of which are characterised by poorly co-oriented grains (1–20 µm wide). Both types of micritic layers contain tangled “thread-like” structures (~40 µm wide) consisting of micritic crystals (1–7 µm wide) that superficially resemble cyanobacterial filaments. These layers either show depletion in Mg and enrichment in Si and Al (type 1), or enrichment in Mg and depletion in Si and Al (type 2). Crystalline layers are 750–1000 µm thick and occur every 1.8–2 cm. They consist of calcite fan-like crystals up to 1 mm in size that are co-oriented, with c-axes perpendicular to the stromatolite layers. These crystals show highly misoriented internal structures similar to those observed in modern freshwater stromatolites, interpreted as imprints of cyanobacterial fascicules. In addition, thin layers of detrital sediment within the crystalline layers separate crystals below and above. The alternation of the two types of micritic layers is interpreted to represent annual cycles of rainy and dry seasons. During rainy seasons, detrital sediment would have been transported onto the stromatolites (type 1). In contrast, precipitation of either aragonite or high-Mg calcite would have been dominant during dry seasons (type 2). Crystalline layers are interpreted to represent decadal climatic events happening every 27–30 years that include sporadic storm events. This study demonstrates the possibility of applying combined EBSD and EDS to stromatolite facies for understanding formative processes. By acquiring quantitative information such as crystal size and morphology, the spatial distribution of elements, and crystal orientation, the approach is helpful in reconstructing paleoclimate in ultra-high resolution.

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Poster presentation

Origin of atypical carbonate caprock assemblage in the Iranian salt diapirs (Paskhand salt diapir, Southern Iran)

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Carbonate units in the Paskhand salt diapir (Zagros Mts., Iran) exhibit field relationships and rock fabrics similar to classical carbonate caprock (CCR) from around the world, but also have features that are in marked contrast to such examples. The most noticeable difference is that its atypical CCR (aCCR) is mostly made up of multigenerational dolostones with isotopically heavy stable carbon and oxygen signatures. Classical CCR assemblages are composed of limestone and have an isotopic light C signature. This is thought to be the consequence of microbial activity that oxidizes hydrocarbons and reduces sulfate, with reductive anhydrite dissolution providing a source of calcium for limestone formation. In the case of the aCCR from the Paskhand salt diapir that genetic framework must be adjusted to integrate a mechanism that supplied magnesium to drive the formation of dolomite (dolostone), while offering an explanation for the unexpected carbon and oxygen isotope compositions of carbonate. Clumped isotope analysis indicates that the multiple stages of aCCR formation produced dolostone recrystallization at temperatures between ~116 and ~271 °C, in a fluid with oxygen stable isotope values between +31 and +39 ‰ (V-SMOW). The regular distribution of stable carbon isotope values throughout all CCR phases shows that only a little amount of carbonate precipitated in later stages in association with hydrocarbon oxidation. Instead of hydrocarbon oxidation linked to sulphate reduction, we hypothesise that contemporaneous dissolved inorganic carbon (DIC) sourced from organic-rich, Infracambrian lithologies during methanogenesis led to the formation of a first generation dolomitic aCCR. This residual, ^{13}C-enriched DIC and magnesium derived from the dissolution of potash intervals provided the reactants consumed during thermal aCCR alteration and dolomite recrystallization.Our results show that a correct interpretation of the mechanism(s) of carbonate alteration in aCCR is critical for reconstructing the history of diapirism in the area, which could in turn provide important information about the source, formation conditions, and quality of hydrocarbon reservoirs in other areas affected by ancient salt tectonics.

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Poster presentation

Stable isotope composition record through the Oligocene–Miocene transition in lacustrine sequences (Ebro Basin, NE Iberia)

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The Oligocene to Miocene Transition (OMT) was characterized by alternating warming and cooling conditions. The OTM began with a warming interval in the latest Oligocene at ≈ 24.8 Ma, followed by a short but large Antarctic ice-sheet expansion (Mi-1 Glaciation). The latter marked the Oligocene–Miocene boundary (OMB), set at 23.03 Ma, causing diverse effects on oceans and continents, though a large-scale decrease in temperature and precipitation is often proposed. The OMT climate has not been described in detail in the continental regions mainly due to the lack of accurately dated records. The Ebro Basin (NE Iberia) contains a well-exposed lacustrine–palustrine carbonate succession, with a magnetostratigraphy encompassing the OMT. A 104 m-thick interval spanning from 23.7 to 22.2 Ma was sampled and $\delta^{13}C$ and $\delta^{18}O$ analyses were performed on calcite of marlstones and carbonate mudstones (N=38) and limestones (N=92). Sample ages were determined by interpolation within each magnetic polarity chron. The $\delta^{18}O$ and $\delta^{13}C$ values are found to be typical of freshwater environments with variable soil-CO_2 influence. The overall evolutions of the $\delta^{13}C$ and $\delta^{18}O$ values decrease through time, except for a slight increase displayed by the $\delta^{18}O$ trend of limestones. The Oligocene record shows a significantly wide $\delta^{13}C$ and $\delta^{18}O$ variability that sharply decreases right after the OMB; the rather steady evolution includes periods of some $\delta^{13}C$ and $\delta^{18}O$ variability. A change in the $\delta^{13}C$ trend occurs at the OMB, from increasing in the Oligocene to decreasing in the Miocene. In contrast, the $\delta^{18}O$ values do not show a clear tendency through the two studied periods, though the average $\delta^{18}O$ value is slightly higher in the Miocene than in the Oligocene. A subtle decreasing–increasing inflection is recorded by the Miocene $\delta^{18}O$ values at ≈ 22.5 Ma. Together, this isotopic evolution across the OMT is interpreted to reflect changes in precipitation/evaporation ratio and temperature in the Ebro Basin that might be the regional expression of the global climatic change related to Mi-1 Glaciation.

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Poster presentation

Climatic periodicity in the Cretaceous synrift lacustrine sediments of the El Castellar Formation (Galve Subbasin, NE Spain)

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The Castillo de Aliaga section, 129 m thick, logged in the late Hauterivian–early Barremian lacustrine El Castellar Formation, consists of two carbonated successions made up of stacked sequences of marls and limestones separated by a 40 m thick interval of mudstones and marls. Three main facies associations associated with expansion–retraction changes of the lake and shallowing sequences of the system have been distinguished: low-energy shallow lake, mixed detritic–carbonated lake, and high-energy lake. The sedimentary sequences are characterized by an evolution from marly or muddy sediments to limestones, which show sub-aerial exposure features (bioturbation, oxidation or brecciation) towards the top of the sequences. The cyclicity study shows three robust sedimentary cycles, with periodicities of 57.3 m, 13.23 m and 3.31 m, which have been attributed, respectively, to the Earth orbital cycles of long (405 kyr) and short (95 kyr) eccentricity, and long precession (22.4 kyr). These orbitally induced climatic cycles have been correlated with sedimentary sequences of lacustrine shallowing of different orders of magnitude observed in the studied sedimentary succession. The long eccentricity cycle (~57.3 m) could be responsible of the largest interbedded clastic interval between the two carbonate ones. The short eccentricity cycle of ~13.2 m corresponds to the main shallowing clastic–carbonate packages recognized, which show, especially in the basal part of the succession, subaerial exposure features in the upper part of the sequences. The ~3.3 m long precession cycle corresponds mainly to marl–limestone bundles. In the sedimentary succession, ten complete and another two incomplete cycles of short eccentricity (95 kyr) have been distinguished, representing a period of ca. 1 Ma for the studied El Castellar Formation (Upper Hauterivian–Lower Barremian).

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Poster presentation

Using stable isotopes in deciphering climate changes from travertine deposits: the case of the Lapis Tiburtinus Succession (Tivoli, Central Italy)

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Travertine deposits are influenced by physical, chemical and biological processes within the environment where they develop. Fluids supersaturated in calcium carbonate, controlled by the interaction between water circulating in carbonate-rocks aquifer and thermal activity, rising up along discontinuities or fractured bedrock, leads at springs where precipitation of travertines takes place. Bounded to the north and to the east by the Apennines range, mainly composed by a Meso–Cenozoic carbonate succession, and to the south by the Aniene River and by the Colli Albani volcanic complex, the Acque Albule Basin (Central Italy) is famous for the deposition of the Lapis Tiburtinus travertine. These deposits developed during the Late Pleistocene (150–30 ka) and concurrently with the last activity of the Colli Albani volcanic complex. Carbon and Oxygen stable isotope ratios analysed in two boreholes drilled from the Lapis Tiburtinus succession permit to identify the sensitivity of travertine depositional system to glacial and interglacial cycles as well as to unravel the complex carbon cycle dynamics recorded within such sedimentary succession. The results obtained, correlated with pollen curves available of Mediterranean area, as well as regional and global oxygen isotope continental and marine curves and calibrated with U/Th dating, allow to identify at least 3 phases of the last interglacial (MIS5 – Marine Isotope Stage 5), revealing that these deposits are sensitive to global climate changes. Moreover, the carbon isotope record shows an influence of groundwater level changes. Positive shifts, occurred during arid phases, associated to a lower groundwater level and an increase CO_2 degassing, inducing a major fractionation effect on carbon isotopes. In contrast, negative shifts occurred in concomitance of humid periods supporting the inhibition of CO_2 degassing and pressure increased, attesting of a rise in groundwater level. Travertine deposits studied to define the tectonic setting and activity of the area where they develop thus potentially can also be used as a tool to understand climate changes and groundwater variations testified in their stable oxygen and carbon isotope signature.

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Poster presentation

Paleoenvironments in the Sierra de las Cabras Ichnofossil Site (Late Miocene, SE Spain): a freshwater wetland in a semi-arid climate

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We present a sedimentological analysis of the Late Miocene carbonate deposits that bear the Sierra de las Cabras ichnofossil site (CBR). The CBR site is located near Jumilla (Murcia) in the Prebetic Zone (Betic Cordillera) and is defined by an exceptional record of >375 footprints spread on three successive stratigraphic surfaces. The ichnites correspond to a diverse vertebrate fauna that includes *Hippipeda*, *Rhynoceripeda*, *Canipeda*, *Felipeda*, *Ursipeda*, *Rodentipeda*, *Fuscinapeda*, and possible *Suipeda* (Herrero et al., 2022, 2023). We assign to the CBR site a latest Tortonian to earliest Messinian age based on stratigraphic and tectonic criteria including the finding of a volcaniclastic bed overlying the ichnite levels. The sequence that includes the CBR is only ~10 m thick and is bounded by unconformities. It mostly consists of thinly bedded marly limestones which show diverse facies, including biopelmicrites with ostracods and gastropods; (dolo)micrites with gypsum pseudomorphs; planar stromatolites; intraclastic breccias, and moss and stem boundstones. It is remarkable the presence of green algae, plants, and diverse cyanobacteria. Pedogenic and subaerial exposure features superimposed to facies include desiccation cracks, micro-nodulization, clotted fabric, pedogenic-ooids, root voids, and Microcodium. The ichnites were imprinted on soft but partially consolidated sediment that in most cases had a plastic behavior. We infer the paleoenvironment of the CBR site as a semi-arid wetland system, with shallow ponds, swamps and marshes that provided habitats for diverse fauna. Carbonate-rich freshwater was provided to the wetland by springs that formed at the foot of a primigenial Sierra de las Cabras. This reconstruction is compatible with changes in paleogeography then experienced by that region, that were determined by the tectonic closure of the Betic Strait (marine seaway that connected Atlantic and Mediterranean up to the early Tortonian) and the subsequent generation of small intra-montane continental basins.

References

Herrero et al. (2022) J Iber Geol. https://doi.org/10.1007/s41513-022-00192-5; Herrero et al. (2023) J Iber Geol. https://doi.org/10.1007/s41513-023-00205-x

Theme 1. Continental carbonates, karst and cave deposits

Special Session 1.1. The response of continental carbonates to (paleo)environmental perturbations: new insights from emergent and old/refined indicators

Poster presentation

Marine influenced low-gradient ephemeral lakes and vegetated marshes forming a palustric–lacustric carbonate setting (latest Cretaceous, Iberian Basin, Spain)

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This study is focused in the Fortanete Fm, a lower Campanian carbonate succession deposited in the south-eastern areas of the Iberian Basin (NE Spain). A detailed sedimentological and stratigraphic study in a 40x80 km area and 10 stratigraphic logs have been done. The Fortanete Fm mainly consists of massive brecciated limestones with gastropods and intervals of whitish and grey charophyte rich marls, that have been classified in two different facies associations (marl facies association – MFA; and limestone facies association – LFA). However, northeastern areas of the basin are dominated by brown to yellow lutites and evaporites, also grouped in a third facies association (evaporite and lutite facies association – ELFA). All these features are interpreted as a palustrine–lacustrine complex environment with three different sedimentary domains associated with the previous mentioned facies associations. A first domain located in the center of the basin with sedimentation of marls rich in charophytes and gastropods (MFA). These features suggest an interpretation of vegetated marshes and low-energy shallow ephemeral lakes with dominant lacustric conditions. In the northwestern and southeastern areas of the basin there are strongly brecciated and bioturbated breccias with abundant continental gastropods and solid development of pseudomicrokarst (LFA). These are interpreted as formed in a palustric setting at the margin of ephemeral lakes with water-level variability. Finally, evaporites and lutites (ELFA) in the northeastern areas could be associated with alluvial mud-plains with higher siliciclastic input and more arid conditions favoring precipitation of evaporites. Therefore, the Fortanete fm represents a great opportunity to compare with similar modern environments such as the Florida everglades and support the hypothesis of palustric–lacustric systems being related to complex mosaics of fresh-water (sometimes marine influenced) environments.

Theme 1. Continental carbonates, karst and cave deposits

Special Session 1.1. The response of continental carbonates to (paleo)environmental perturbations: new insights from emergent and old/refined indicators

Poster presentation

Controlling factors for quality of Lower Jurassic nonmarine shale reservoirs in Sichuan Basin, China

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Industrial gas flows have been yielded in the lower Jurassic nonmarine shale in Sichuan Basin in recent years, highlighting the potential of shale gas resources in the shale reservoir. The purpose of this study is to identify the key factors that control the reservoir quality of nonmarine shale in the Lower Jurassic of the Sichuan Basin. A comprehensive approach that includes thin-section observation, whole-rock X-ray diffraction, helium gas for pore permeability, elemental and organic geochemistry, and scanning electron microscopy was used. The study reveals the type and composition of rocks, the structure, type, and storage capacity of the pores, and the factors controlling pore growth. Results indicate that clay minerals, quartz, and carbonate minerals are the main constituent minerals of the Lower Jurassic nonmarine shales, with clay minerals and quartz being dominant and carbonate minerals being locally enriched. The lithology of the shale reservoir consists of clay shales, quartz shales, shell shales, and silt shales. Clay shales and mesoscopic shales in the Da'anzhai and Dongyuemiao member are high-quality shale reservoirs, with relatively high organic matter content and high reservoir capacity, with an average porosity of about 3.9%. Pores in the shales are primarily intergranular pores between clay minerals and other terrigenous debris, followed by organic-matter pores and some local micro-cracks. The intergranular pores are strongly influenced by clay mineral and compaction intensity, with compaction being the main factor controlling the quality of shale reservoir. Semi-deep lakes are favorable depositional environments for the preservation of organic matter. Based on these findings, we propose a new method for predicting high-quality shale reservoirs: by identifying undercompacted zones in semi-deep lacustrine shale formations.

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Poster presentation

Paleoenvironmental reconstruction of Bonan Sag, Bohai Bay Basin: evidence from aragonite laminae

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Lacustrine laminated shales are often varves representing annual rhythmic deposition, potentially preserving information about the tectonic setting, paleoaltimetry, paleoenvironments, variations in lake water conditions (evaporative concentration, source waters, temperature) and biological activity. Aragonite lamina, which was found from the first member of Shahejie formation, Eocene strata in Bonan Sag, Bohai Bay Basin, provide significant paleolake signatures. Mineralogical and geochemical analyses were conducted on alternating yellowish and greyish aragonite lamina. The yellowish layers are mainly composed of aragonite crystals and algae skeleton, while the greyish layers contain less aragonite and fewer organic remnants that accumulate among debris with sporadic framboidal pyrite. The $\delta^{13}C$ values of yellowish layers are remarkably positive, while the $\delta^{18}O$ values are slightly negative. Consequently, in the warm season, due to the high salinity and evaporation effects, Mg/Ca ratios were elevated, and algal blooms caused a decrease in the CO_2 content, leading to higher pH values, which were favourable for the precipitation of aragonite instead of other carbonate minerals. Moreover, slightly negative $\delta^{18}O$ values in yellowish layers are interpreted as the result of intense inflow during warm seasons, which leads to less precipitation of organic matter and debris. The greyish layers in cold seasons are the opposite. The results from this study show that understanding the lacustrine lamina origin of Bonan Sag is essential for paleoenvironmental and paleoclimate interpretations.

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Special Session 1.2. Cave sediments – archives of past environmental changes

Oral presentation

Varve-like sediments in caves from the northern rim of the Dachstein Massif (Austria)

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Fine-grained clastic sediments with bright and dark laminae, informally called "Bright Cave Loam" (BCL) are present in caves of the Dachstein Massif below an altitude of about 1,700 m a.s.l. The Dachstein Massif, with an areal extent of 580 km^2, is one of the largest karst massifs in Austria. The BCL represents the topmost layer in a number of caves of the area and has a maximum thickness of 6 m. In the past, the mm- to cm-thick laminations of the BCL were assumed to be glacio-lacustrine varves caused by seasonal or longer climatic rhythms. To investigate this theory, samples were taken from two different caves, Hirlatzhöhle (from c. 1,000 m a.s.l.) and Dachstein–Mammuthöhle (c. 1,400 m a.s.l.).

Sedimentological methods used were grain size analysis and X-ray diffraction (XRD) for the bulk- and clay mineralogy. Wherever possible, individual laminae of the BCL were analysed separately. The results of the bulk mineralogy show that darker laminae mainly consist of calcite (32–75 %) with secondary amounts of quartz (2–5 %), dolomite, ankerite, and traces of K-feldspar and goethite. In the dark laminae clay minerals are more abundant (11–60 %) than in the bright laminae. Overall, the bright laminae have the same mineralogical constituents, but show slightly higher amounts of calcite and quartz. Clay mineralogy shows a laminae dependent pattern for all clay minerals except smectite. Illite is the most abundant clay mineral and is, together with kaolinite and chlorite, slightly enriched in the darker laminae. The bright and dark laminae can also be distinguished by grain size analysis. The dark laminae have a higher percentage of clay-sized particles. The maximum grain size of both lamina types is coarse silt. Components up to medium silt are very well sorted.
In conclusion, the BCL was likely formed under conditions of slack-water facies and can be interpreted as a result of glacial backflooding in the Pleistocene. This also explains the altitude control of the BCL. The bright, carbonate-rich, and coarser-grained laminae originate from more energetic meltwater during spring and summer; in winter there is lower discharge, the remaining clay minerals are sedimented and result in the thin, darker laminae. The studied sediments can thus be interpreted as varves.

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Special Session 1.2. Cave sediments – archives of past environmental changes

Oral presentation

Changes in cave sedimentation mechanisms during the Late Quaternary: an example from the Lower Cerovačka Cave, Croatia

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Situated within the NE slopes of Mt. Crnopac (Dinaric karst, Republic of Croatia), the Lower Cerovačka Cave represents a subhorizontal hydrologically inactive cave in today's vadose zone. During recent archaeological excavations 120 m from the entrance, the test trench penetrated an undisturbed sequence of clastic cave sediments with a thickness of 1.8 m. Considering that caves are efficient sediment traps, detailed geological investigations were carried out to characterize the sediments, determine their origin, depositional environment, and degree of environmental changes during their deposition in the main cave channel. Using the multiproxy approach, a combination of several sedimentological, mineralogical, and paleontological analyses was performed. The stratigraphic calibration was made using the luminescence dating of detrital sediments and the radiocarbon dating of speleothems. The lithofacies analyses revealed several stages in the development of channel filling on the investigated site, from collapse processes, through chaotic sediments with indications of redeposition, followed by the deposition in stagnant water environments and finally, anthropogenic influence. Deposition took place in various conditions, from a pronounced cold and dry climate during the Pleistocene stages recorded at the base of the profile to humid periods with anthropogenic influence during the Holocene period recorded at the very top of the profile. The allochthonous origin of a clastic detritus is related to the source rocks and sediments found in the wider River Otuča catchment area. Although these deposits were previously considered Pleistocene sediments (based on the fossil fauna findings), here, for the first time, a stratigraphic calibration based on numerical methods has been performed. Luminescence dating indicates that deposition of the allochthonous channel fill took place around or after 54,000 years BP in the initial turbulent phase. Deposition in the calm water environment of the submerged cave channel followed and is related to the environmental change around the period of 19,500 years ago. The end of deposition in the aquatic environment occurred before the Late Bronze Age and is related to the permanent neotectonic uplift of a wider area along the main NW–SE faults.

Theme 1. Continental carbonates, karst and cave deposits

Special Session 1.2. Cave sediments – archives of past environmental changes

Oral presentation

Carbonates that defy gravity

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Cave carbonates, seemingly growing in defiance of gravity, have attracted the community's interest for more than a century. This contribution focuses on `helictites´, contorted vermiform speleothems with central capillaries. The crystals that build aragonitic helictites display uncommon board, platy, rod and lath-shaped morphologies and flat or pseudo-prismatic terminations. These differ significantly from many aragonite crystal fabrics in conventional stalactites and stalagmites forming from dripping or flowing water. Calcitic helictites, in contrast, are best described as a composite crystal fabric consisting of fibrous mesocrystals. The mechanisms controlling the complex and irregular growth forms of these speleothems remain poorly understood. Particularly, the fact that helictites show both length and thickness growth has been debated in the context of capillary physics. Here, we present evidence from calcitic and aragonitic helictites in several caves in Germany and combine field monitoring with experimental work in the lab. The surfaces of actively growing helictites in caves were treated with a colouring agent at the beginning of the monitoring period in fall 2022 to highlight growth during the humid winter months. Moreover, helictites were attached to capillaries and a peristaltic pump providing supersaturated water to the helictite base in a laboratory experiment to study growth modes under controlled conditions. The results indicate that helictite mineralogy, fabric and morphology are likely controlled by a parameter set characterised by tipping points that are highly sensitive to even minor environmental and crystallographic changes. Monitoring and experimental work results are presented in a process-oriented context.

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Oral presentation

Sedimentology and provenance of unroofed cave sediments as paleoflow proxies, Laški Ravnik (central Slovenia)

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Unroofed caves and their sediments are ancient cave systems that underwent a transition from phreatic to vadose conditions until they were surface-exposed due to denudation. The preservation of caves and their deposits depends on the degree of denudation and it varies from barely to completely preserved passages. Cave-fill sediments are predominantly allochtonous in origin and are mostly transported and deposited by episodic, high-energy flood flows. Therefore, understanding the sedimentological processes and the provenance of these deposits is of vital importance in understanding the evolution of the paleo-hydrological network of subterranean rivers. Here we present the depositional dynamics and provenance of clastic deposits from the unroofed cave in Laški Ravnik (central Slovenia). Laški Ravnik is part of a low-relief corridor extremely rich in karst surface forms, namely solution dolines. Investigated unroofed cave was formed in the Late Jurassic carbonates of the Adriatic Carbonate Platform and was completely filled with clastic sediments during its active phase. The cave deposits are mostly represented by bedded polymictic, clast-supported, well-sorted, granule to pebble sized conglomerate (facies Gh), while lenctinular beds and lenses of polymictic, pebbly sandstone (facies Ss) are rare. Imbrication is common, while normal grading is rare. The majority of the clasts consists of Early Jurassic carbonate rocks, while Triassic chert and quartz clasts are less common. In the upper part, the clastic deposits were intercalated by flowstone layer. Facies Gh represents channel lag deposit or small planar or massive bedded bar developed by ephemeral high-energy dynamic events, while facies Ss was formed either by rapid channel-fill or by lateral accretion of side bar in fluvial channel. The facies association, sedimentary structures, and architectural elements of clastic deposits in the investigated unroofed cave indicate the existence of a subterranean fluvial environment characterised by high-energy, short-lived flood events under epiphreatic or vadose conditions. Provenance analysis and paleoflow indicators (clast imbrication) points to paleoflow predominantly from northwest to southeast during the active phase of the cave. Which is in contrast to the current underground flow regime.

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Special Session 1.2. Cave sediments – archives of past environmental changes

Oral presentation

Mid-to-Late Holocene climate changes in the Southwestern USA inferred from stable isotope analysis of ice in lava tube caves

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The Southwest region of the United States has a long history of experiencing droughts and challenging climate conditions, even prior to the widespread impact of human-induced climate change. This study aims to reconstruct Mid-to-Late Holocene hydroclimate changes using oxygen and hydrogen isotopic composition of ice cores recovered from three lava tube caves in the El Malpais National Monument (New Mexico, USA). The $\delta^{18}O$ and $\delta^{2}H$ isotopic composition was measured in aliquots of ice-melted water from three cores using a Picarro isotopic water analyzer. The chronology is based on radiocarbon dating of charcoal particles recovered from two ice cores, as well as U-series ages determined on selected ice-melted water samples. A well-constrained age-depth model exists only for the ice in Cave 29, which accumulated between 3600 and 1000 cal yr BP. The $\delta^{18}O$ values range between -4 and -13‰ (VSMOW), meaning the source of moisture transported into the investigated area is mainly from either the Gulf of Mexico and/or California (-2 to -6‰) or Pacific Ocean (-8 to -14‰). The most remarkable feature in all three ice cores is a large shift (5 to 8‰) towards more negative values. These pronounced negative excursions are interpreted to indicate accumulation of ice in lava tubes from snow-melted water arriving predominantly from the Pacific during the winter. The frequency of precipitation in the Southwest is largely modulated by the El Niño Southern Oscillation (ENSO), with a notable increase of winter moisture during El Niño years. In contrast, less negative isotopic values in ice suggest a strong North American Monsoon (NAM) that carries ^{18}O-enriched precipitation from the Gulf of Mexico during the summer. We speculate that during some heavy summer NAM rainfalls, ice melting occurs in the upper few centimeters of the ice blocks, allowing for waters that have different isotopic contents to mix. Therefore, we can relate $\delta^{18}O$ time series in ice to climate indices describing the occurrence of ENSO or the NAM, which in turn, allows us to link prolonged drought periods with different combinations of ENSO, NAM, and other large-scale modes of climate variability.

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Special Session 1.2. Cave sediments – archives of past environmental changes

Oral presentation

Great Blue Hole: a 7000-year-long sedimentological archive of tropical cyclone frequency at annual resolution

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Special sedimentological archives allow the observation of cyclone frequency patterns several thousand years back in time. Recently, numerous paleo-cyclone reconstructions have been obtained from sediment cores collected in coastal sinkholes and marine blue holes in the tropical western Atlantic. These geomorphological structures serve in the local sedimentation system as giant sediment traps for coarser allochthonous particles, mobilized from adjacent areas by passing cyclones. Coarse particles are usually not transported to the caverns floor during fair-weather conditions, but they are deposited as lobe-shaped event beds after suspensional carriage by storm waves and surges. The 320 m wide and 125 m deep Great Blue Hole offshore Belize is a cyclone frequency archive worth exploring due to its anoxic bottom-water conditions and a high potential to recover undisturbed and varved Holocene and Pleistocene deposits. In June 2022, a 30-m-long sediment core was extracted to develop one of the longest continuous and annually-resolved tropical cyclone archives of the Caribbean Basin. The core base was dated to 12.5 ka BP by applying the ^{14}C-AMS radiocarbon method on bulk marine organic. Sedimentological and palynological analyses point to an initial cenote-like depositional setting that experienced a rising marine influence starting around 7.2 ka BP, which led to brackish and restricted marine conditions until 5.7 ka BP. After this time, full marine conditions similar as today have persisted in the Great Blue Hole. An alternation of fine-grained and greenish fair-weather varves and coarser light-brown tempestites occurs in both the restricted marine (28.6–24.6 m) and the fully marine core sections (24.6–0 m). These findings result in a ~7000-year-long storm frequency reconstruction at annual resolution, continuously encompassing the mid-to-late Holocene. Our reconstruction highlights an interval of elevated storm frequency in the expiring Holocene Climate Optimum (6.8–5.8 ka BP). This mid-Holocene peak phase is followed by a period of generally lower activity (5.8–3.0 ka BP), culminating in an outstanding high-frequency interval (3.4–3.2 ka BP). From 3.0 ka BP on, a persistent increase towards higher storm frequency occurs with two maxima during the Medieval Warm Period and the present day climate stage.

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Special Session 1.2. Cave sediments – archives of past environmental changes

Oral presentation

Sedimentological record in the Mio–Quaternary speleogenetic evolution of the Loza Cave System (Slavinski ravnik, SW Slovenia)

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The Slavinski ravnik corrosional plain represents a contact karst area, located south of the Postojna basin in the NW part of the Dinarides, formed at the transition between flysch and carbonate rocks. The area is strongly affected by regional tectonic uplift, climatic changes, erosion, and sedimentation from impermeable rocks. The main contribution of allogenic sedimentation of the Slavinski ravnik is possible through ponors. Continuous development can be observed through the course of the river Rakuliščica and its ponor at the end of the Blind valleys Biščevci and Sajevško polje. With the help of uplifting and the lowering of the water table, the ponor gradually adapted in time and created the Loza cave system, which appears in several active and relict horizontal and vertical segments. It consists of an intermittent ponor Markov spodmol, an epiphreatic cave Vodna jama v Lozi, an unroofed cave Brezstropa jama v Lozi, and several different bypass channels and shafts (e.g. Šimčev spodmol, Spodmol v Selški Lozi), representing side passages of the main unroofed cave. In the cave system, various sedimentary sections of allogenic sediments, covered or intercalated with speleothems were studied using a multi-proxy approach (for paleomagnetic, paleontological, U–Th, and mineralogical analyses), which allowed us to decipher the main factors of morphogenesis, speleogenesis and changes in the underground karst hydrological zones over time. The mineral composition of allogenic sediments is consistent with the transport from flysch of the Postojna Basin. The paleomagnetic results of sampled sections reveal both normal and reverse polarities; some of them show an eastward counterclockwise rotation of more than 35° or even clockwise rotation, which represents the oldest allogenic sedimentation in this region. The sedimentation phases observed in the cave Šimčev spodmol and Markov spodmol reveal a complex sedimentological and speleogenetic history, while the formation of the longest unroofed cave in Slovenia – the Brezstropa jama v Lozi, is among the oldests. In summary, the Loza cave system represents a unique, comprehensive study site with a complete speleogenetic evolution in a relatively small contact karst area, in the long Mio–Quaternary timeframe, which is particularly evidenced by the extensive studies of the sedimentological record.

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Special Session 1.2. Cave sediments – archives of past environmental changes

Oral presentation

Sedimentation in caves: clastic cave sediments and speleothem multiproxy datasets; examples from Slovenia

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Sediments from different karst environments (cave and surface) represent an archive of past geological and environmental records and are often the only deposits representing the terrestrial phase of landscape evolution. Cave sediments are well preserved in the underground because they are protected from weathering by daily and seasonal variations in surface climate. Allogenic sediments, transported to the subsurface as a load of a sinking river, reflect changes in river catchment(s) due to tectonic or climatic changes. They may contain information on: the mechanics of sediment transport, the mode of deposition (sedimentary structures), sedimentary facies (cave-specific environments), the origin of clastic sediments, diagenesis, paleoclimate, and timing of sedimentation (age). Due to their depositional mechanism, cave sediments represent the most complex terrestrial depositional system (tube system): the law of superposition is frequently violated (shrinking, slumping, burrowing, sandwiching, etc.); both heteropic and heterotopic facies occur (differ laterally in both age and type); depositional rates can vary extremely in both vadose and phreatic karst hydrological zones, and their calculation is problematic due to numerous hiatuses and subsequent erosion; reworking and redeposition along the same cave passage/system are very common. Calcite speleothems, typically growing under epiphreatic or vadose conditions of karst hydrological zones, are suitable for dating by various methods and also for studies of past climatic and environmental changes. In Slovenia (mainly NW part of the Dinaric Karst), we have studied multi-proxy records from Plio-Quaternary cave sediments. Paleomagnetic (including thermal /TD/ and alternating field /AF/ demagnetization, magnetic susceptibility) and magnetostratigraphic data were calibrated, when possible, by U-series and radiocarbon dating, oxygen isotope stratigraphy, paleontological and geomorphological results. The oldest sediments (>5 Ma) currently occur in near-surface and unroofed caves that reached the surface through karst denudation and tectonic uplift. The cave sediments also reflect spelogenetic and karst landscape evolution, i.e., tectonic regimes, catchment evolution and/or climatic changes with flooding during the Cenozoic.

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Poster presentation

Paleomagnetic and rock magnetic investigations of cave sediments in Lipiška Jama: insight into Classical Karst (SW Slovenia) evolution

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The Lipiška jama Cave at the south edge of the Kras Plateau (Slovenia) is a 1,400 m long, inclined to the SSW. It is recently functioning in epiphreatic and vadose regimes. Three allogenic sedimentary sections, each 2 to 3 m thick, deposited in three different levels of the same cave passage (i.e. Kozinski rov), were sampled (bottom, middle, top). With the exception of the bottom level section, which was disturbed by slides and slumps, the other two sections were sampled using high-resolution method. For magnetomineralogical characterization of the sediments rock magnetic methods such as acquisition of isothermal remanent magnetization, S-ratio, anisotropy of magnetic susceptibility (AMS), etc., were used. Magnetic susceptibility shows a wide variation of values in all three sections. A low coercivity mineral (e. g. magnetite) is identified as the main carrier of magnetization. The AMS shows dominantly oblate fabric, which corresponds to fine-grain sedimentation. Alternating field demagnetization was applied to determine characteristic remanent magnetization (ChRM). Primary magnetization, and the presence of both normal (N) and reverse (R) polarity samples, were determined. The section in the bottom level of the cave passage, which was extensively influenced by post-depositional features, displays a chaotic distribution of the ChRM components. The section in the middle level of the cave passage reveals R and N polarity zone within the allogenic sediment with a nearly antipodal position of their mean directions, as well as basal flowstone with R polarity. The highest positioned section reveals mainly R polarity and occasionally N polarity samples. Although the homogenous non-laminated clay forms this sedimentary sequence, AMS parameters suggest some samples suspected of slumps behaviour. The presence of R polarity zones in two studied sections in the Lipiška jama suggests an age at least within the Matuyama Chron. Correlation with other sections in the area will help the understanding the evolution of the Classical Karst.

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Theme 1. Continental carbonates, karst and cave deposits

Special Session 1.2. Cave sediments – archives of past environmental changes

Poster presentation

The sedimentary sequence of the Račiška pečina

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The sedimentary sequence of the flowstone dome from the Račiška pečina represents an exceptional chronostratigraphic record from the late Pliocene to the present. The studied sedimentary sequence was mainly characterized by the deposition of layers of extensive speleothem domes interrupted by hiatuses of very different duration. The domes began to grow as the cave became disconnected from the original hydrological system. The deposition of speleothem layers was frequently interrupted by sedimentation of clay to silt infiltrated from the surface above the cave. Pleistocene fauna was locally present in them, including specimens of the subterranean gastropod species *Zospeum* sp. The studied section at the mouth of a narrow side passage into the main cave passage is about 13 m long and 3 m high. The thickness of the composite sampled thickness was 6.34 m. The section is vertically composed of three main lithostratigraphic units: (1) the lower part: brown to reddish-brown, massive but porous speleothems, with some interbeds of red clays, two angular unconformities, and the remains of broken stalagmites; (2) the middle part: subhorizontally laminated, mostly porous flowstones intercalated by calcite rimstones and thick layers of red clay with rare fauna remains, very poorly preserved, fragile, and composed primarily of small enamel fragments; and (3) upper part: massive, mostly laminated flowstones with two lens-like interbeds of yellow grey clay with large bone fragments and teeth (*Ursus* ex gr. *spelaeus*; U-series dated to > ±72 ka). Some of the top flowstone layers contain black laminae enriched layers (radiocarbon dating to ±11 ka, ±9 ka, and ±3 ka) that can be attributed to repeated Paleolithic and Neolithic human settlements in the cave. A detailed chronology of the Račiška pečina section was established by combining magnetostratigraphy and isotope-oxygen stratigraphy and correlated with paleontological, U-series, and radiocarbon results. The sequence records geochronological and environmental data from the last 3.4 Ma, including the Pliocene-Quaternary transition and the Matuyama/Brunhes boundary, which is characterized by dramatic changes in stable isotope composition and trace elements.

Theme 1. Continental carbonates, karst and cave deposits

General Session

Oral presentation

Diagenesis of Palaeozoic–Mesozoic Tethys Ocean carbonate succession – Oman Mountains

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This research studies the uppermost unit of Kharus Formation (Cambrian) and the Autochthonous Akhdar Group (Permian–Triassic). The aim is to explain the diagenetic history of the Palaeozoic–Mesozoic Tethys Ocean carbonates from the Oman Mountains. Schematic paragenetic phases are determined for the different processes inferred from the petrographic and geochemical study. Petrographic, geochemical, and field observations indicate that the sequences underwent different stages of dolomitization that produced rocks inheriting the original host rock textures and structures and rocks with complete obliteration of the pre-existing textures. The top part of the Kharus Formation consists of pervasively dolomitized units, whereas dolomites belonging to the Autochthonous Akhdar Group display variable degrees of structural and textural preservation. The evidence suggests very early dolomitization in a relatively short time interval for the Permian–Triassic carbonates. The preserved depositional features in the Permian–Triassic carbonates indicate deposition in shallow marine environments with variable energy levels. Eight facies are inferred: stromatolites, mudstones, wackestones, intraformational breccias, grainstones, packstones and grain/packstones. Five paragenetic phases are determined to explain the type of dolomitization and to indicate the type and severity of diagenesis that affected the Palaeozoic–Mesozoic carbonates. Method used to fulfil this research started by sampling of the Palaeozoic–Mesozoic carbonates after careful examination of topographic and geologic maps, and aerial photographs. Sampling was along Wadi Hijir a tributary of Wadi Bani Kharus at Jabal Nakhal, Jebel Akhdar, Wadi Al Bih, Wadi Hagil, and Jebel Sumeini. Then, examination of uncovered thin sections which were stained with potassium ferricyanide and Alizarin Red-S for classification of calcite and dolomite content of the rocks. Polished thin sections were examined by polarizing microscope, scanning electron microscopy, cathodoluminescence microscope, and electron microprobe. Some samples were chosen for X-ray diffraction and isotope analysis which are either whole-rock samples or separated dolomite crystals displaying crystal size and texture variations.

Theme 1. Continental carbonates, karst and cave deposits

General Session

Oral presentation

Genesis of ferruginous grain coatings in palustrine limestones, the Early Jurassic of India

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Formation of calcareous coated grains like ooids and oncoids have been extensively researched. In contrast, the genesis of ferruginous ooids is less clear. Radically different processes like surficial weathering, hydrothermal exhalation and microbial-activity have been advocated for the source of iron and development of the cortex. Modern examples are sparse and from marine environments affected by igneous activity. Based on field, microscopic and mineralogical observations, we present the characteristics of ferruginous coatings around the grains, occurring in freshwater, palustrine limestones of the Early Jurassic syn-rift strata belonging to a continental rift basin of India. These grains occur in the basal limestone bed of an approx. 25 m thick succession of alternating (meter-scale) palustrine limestones and shales (black-yellow-green). Shells of aquatic bivalves, plant remains, chert nodules, as well as layers of barite and gypsum occur throughout the succession. The limestones show features indicative of repeated desiccation, pedogenesis, and microbial mat formation. A few, thin, wedge-shaped, flood-derived cross-bedded sandstones occur locally. This palustrine succession overlies distal alluvial and lacustrine deposits (laminated red and green siliciclastic mudstones containing thin gypsum layers). The basal limestone bed (1–3 m thick) is nodular in character. In it sand-size coated grains, chert fragments and quartz clasts float in a micritic groundmass. Nucleus of the coated grains is made up of dark and amorphous hematite–goethite with small, angular quartz grains, embedded in it. The cortex is mm-thick. It is made up of numerous, thin, wavy laminae of goethite with very small quartz fragments trapped between the lamina. For most grains, the outer part of the cortex has been replaced by calcite spars, to some extent. Proximity of depo-centre to the basin margin faults of the rift valley and their association with evaporite minerals and sub-aerially weathered microbialites, makes these ferruginous coatings ideally poised for a comparative assessment of various hypotheses of solute supply and precipitation. Our observations suggest that the coatings formed due to microbially mediated precipitation of iron oxide-hydroxides in hydrothermally (hot spring) influenced pools.

Theme 1. Continental carbonates, karst and cave deposits

General Session

Oral presentation

Characteristics of differential distribution of fracture–cavity karst reservoirs in different carbonate sedimentary environments in Tabei area, Tarim Basin

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Carbonate fracture–cave reservoir is an important reservoir type in the Tarim Basin, mainly concentrated in the middle and upper Ordovician Yijianfang and Yingshan Formation. It is located in the caves and fissures below an unconformity surface, and is the main reservoir space and percolation channel. Although some scholars have started to focus on the karst system of the whole region in recent years, the karst features on a complete fracture zone have not been subdivided yet. This study selects a typical strike-slip fracture zone in the Tabei area, covering a variety of karst features.The Ordovician strata along the strike-slip fault zone have a large difference in elevation from north to south, the scale of karst development and reservoir structure are diverse. Using geochemical analysis, field outcrops, ground-penetrating radar, drilling data, and logging data, combined with the interpretation of regional Ordovician strike-slip fractures, palaeo-landscape mapping of karst exposures, hydrothermal channel mapping, static mapping of suture cavities and analysis of production dynamic data results, a study on the palaeokarst development pattern controlled by various factors was carried out.The results show that: (i) Atmospheric freshwater and hydrothermal karst jointly contributed to the formation of the current karst reservoir space; (ii) multiple karst phases have a certain matching relationship in time and space; (iii) the atmospheric freshwater karst system was likely formed for the most part in the middle and late Garidonian–early Hessian period, then the formation of a large number of palaeo-river networks during the exposure period played an important role in the development of karst; (iii) the palaeo-river networks, stratigraphic acute-extinction line, stratigraphic carbonate content and the degree of fracture development jointly controlled the degree of karst development and zoning characteristics; (iv) the development of carbonate fracture–cave reservoirs gradually transitioned from multi-factor control to fracture control; (v) hydrothermal karst channels are closely related to Permian volcanic channels, and their matching relationship controled, to some extent, the karst development and hydrocarbon formation in some areas.

Theme 1. Continental carbonates, karst and cave deposits

General Session

Oral presentation

Controls in polygenetic karst from the Upper Jurassic rimmed carbonate platform in offshore Kenitra, Morocco

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Based on a new 3D seismic acquired in the Moroccan offshore and nearby well tops, we investigate the types of karsts in the eastern-rimmed carbonate paleomargin of the young Atlantic Ocean during the Late Jurassic. The aim of this study is to describe tectonic, eustatic and stratigraphic controls for the development of the three observed type of karst (syngenetic, epigenic and hypogenic). The carbonate platform was developed atop the footwall of a tilted block, associated with the necking fault of the Central Atlantic rifting. Abundant truncation surfaces at the top of the carbonate platform affected both to the margin and the inner platform. The reflector truncations and the thickness variations suggest coeval sedimentation in the half-graben, and likely subaerial erosion in the margin. The high frequency cycles presenting subaerial erosion, and probably syngenetic karst, were due to the sea level variations associated with 4th order eustatic cycles and differential half-graben subsidence during the rifting. An incised valley towards the southwest was significantly developed probably through a prior inlet between the north and south shelf-edge reef complexes. The incision (100 m approx.) is interpreted due to 3rd order eustatic cycles originated during the Early Cretaceous regression. During low sea level stage, a juvenile vadose–phreatic karst was developed. High amplitude reflectors with vertical orientation suggest a locally well-developed vadose cave system. The vertical cave system is rooted in two different subhorizontal cave trends, dipping with low angle respect the bedding. Locally, the underlain aquitard on top of the tilted block acted as a hydraulic barrier and produced the low angle paleo-phreatic levels dipping toward the basin. Concave-up reflector disruptions show high amplitudes, circular-like horizontal sections and vertical stacking, being interpreted as hypogenic karst collapses. The deep-seated karst affected mostly the back-reef carbonate platform. Dip attribute maps suggest that the collapses are in clusters next to fault lineaments, independent of their strike. Three families of collapses are related to (1) compaction of the near Lower Cretaceous clastic prograding complex unit, (2) the Late Cretaceous–Early Tertiary compression (?), and (3) Miocene Betic-Rif compression.

Theme 1. Continental carbonates, karst and cave deposits

General Session

Oral presentation

Hypogenic void systems in Mississippian carbonates (UK) and implications for geothermal heat production

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Hypogenic void-conduit systems may comprise both non-stratabound and stratabound components that display morphological features of rising flow. They are formed by upward-flowing fluids, with dissolution attributable to fluid cooling, fluid mixing, changes in redox and/or pH due to injection of CO_2 or H_2S-rich water and pressure. Despite an increasing number of studies of hypogenic void-conduit systems, they are still less well characterised than epigenic systems that are formed by direct surface recharge.

Non-stratabound cavities of possible hypogenic origin intercepted by epigenic caves and mines, and sometimes exhumed within outcrops, have been recognised in Mississippian carbonates on the Derbyshire Platform, Northern England (UK). These carbonates are potential geothermal targets for low–medium enthalpy heat. Such cavities include: 1) open vertical and sub-vertical cavities; 2) partly to completely mineralised cavities with hydrothermal minerals; and 3) calcite-lined and calcite-filled cavities. Calcite in the latter is often very coarsely crystalline, with well-formed crystals commonly >5 cm diameter, that represent the last cementation event. Some of these cavities may contain a later sediment fill.

This study assesses relationships between hypogene cavity occurrence, fill, morphology, size, location and geological context and the timing of hypogene development, including association with faults, stratal architecture, and diagenetic phases. It combines geological and geochemical analysis, which will be used as constraints for numerical models that aim to better understand the genesis and evolution of hypogene cavities and assess their potential role as fluid pathways. Preliminary analysis of the coarsely crystalline calcite show that they have low $\delta^{18}O$, probably reflecting precipitation at high temperature or from isotopically depleted groundwater. Some crystals have low $\delta^{13}C$ suggesting the influence of meteoric water, organic maturation, and/or magmatic CO_2.

Theme 1. Continental carbonates, karst and cave deposits

General Session

Oral presentation

Assessing the age and evolution of a 30 Ma old karstic system by in-situ U–Pb dating of calcite cements

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Determining the onset age of karstification is challenging since this phenomenon implies the dissolution and, thus, the removal and transport of a former solid material. One possible solution to better estimate the age of karstification is to date the first calcite cements that precipitate in the dissolved cavities. However, this solution is tricky to apply when the cements are too old for U–Th dating or too thin for U–Pb dilution dating. This study highlights the in-situ U–Pb dating by LA-ICP-MS of calcite cements from an epigenic karst in the early Oligocene lacustrine–palustrine carbonates of the Paris Basin (France). With this method, 160 µm-thin calcite cement generations can be dated. Thirty-two ages were obtained on calcite rafts and eleven on calcite cements along the karstic walls. These results show that lithification and dissolution of carbonates occurred very early, close to the age of the host deposits between 32 and 28 Ma and that karstic development continued until the early Miocene at 20 Ma. The presence of ostracods and intraclasts trapped between early Oligocene calcite rafts suggests that the karst developed while lacustrine–palustrine sediments formed at the surface. This early dissolution episode is related to the Western Europe geodynamic evolution and the uplift of the basin, leading to a significant Chattian sedimentary hiatus in the basin. We demonstrate that U–Pb dating of calcite cements allows to constrain the beginning of dissolution in continental carbonates and to reconstruct dissolution, cementation, and filling steps of karstic cavities.

Theme 1. Continental carbonates, karst and cave deposits

General Session

Oral presentation

Relative sea level changes recorded in the stratigraphic position of paleokarst caves/cavities and associated cave sediments; Podgrad, SW Slovenia

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The studied paleokarst corresponds to an uplifted peripheral foreland bulge. At the K–T boundary, Upper Cretaceous diagenetically immature eogenetic carbonates of the northern sector of the Adriatic Carbonate Platform were subaerially exposed, karstified, and subsequently covered by Upper Paleocene to Lower Eocene palustrine limestone. The phreatic paleokarst caves/cavities are located in various positions with respect to the paleokarst surface, the deepest being about 75 m below the surface. Three indistinct horizons with caves/cavities and intermediate vugs were recognised. Subsequently, all voids were completely filled with detrital sediments and speleothems in the phreatic and vadose zones. In general, the phreatic cavities of the lower two horizons are geopetally filled with mudstone derived from incomplete dissolution of the host rock and overlain by coarse-grained, blocky calcite. Shallower below the paleokarst surface, a large phreatic cave of the third horizon is filled with flowstone overlain by reddish micritic carbonate sediment with intercalated calcite rafts. In the upper part of the cave, the sediments derived from the paleokarst surface gradually become more abundant. Besides the filled cavities and vugs, the second horizon is characterised by an abundant occurrence of oxidised disseminated pyrite. Vadose channels, which may also cut through the cave sediments, are mainly filled with "pedogenic" material derived from the paleokarst surface. Immediately prior to marine transgression over the paleokarst surface, some cavities were filled with marine-derived microturbidites. In general, the diversity of cavity fillings and the amount of surface material decrease with depth from the paleokarst surface. Below the paleokarst surface, the $\delta^{13}C$ and $\delta^{18}O$ values of the host rock and cave/cavity deposits show good correlation with trends significant for meteoric diagenesis. Given the characteristics of the caves/cavities, their distribution, the internal deposits, the location of the disseminated pyrite, and the distribution of the vadose channels, it is hypothesised that the water table and associated freshwater lens with its mixing zone fluctuated during the paleokarst period, as reflected by short-term subaerial exposure events in the adjacent and overlying palustrine deposits.

Theme 1. Continental carbonates, karst and cave deposits

General Session

Oral presentation

Using southern Guizhou modern karst systems as analogs for the Ordovician paleokarst reservoirs in Shunbei oilfield, Tarim Basin, NW China

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There have high uncertainties in paleokarst reservoir exploration due to the spatial complexity. Modern karsts can be ideal analogs for paleokarst reservoir modelings. However, how to exactly translate karst hydrogeomorphology knowledge into practical applications is highly challenging. A combination of field, petrographic, CT, electrical resistivity tomography, and LIDAR analyses can constrain different-scale karst features, and evolutionary model of Guizhou modern karst. We described different degree of karstification, and size, distribution, and geometry of karst features with millimeter–kilometer scales. Faults/fractures affect the flow pathways of fluids and play primary controls on different scales of karst features and the extent of karstification. Thus, a dynamic evolutionary model is established, including initial, youth, and mature stages, illustrating the critical controlling effects of fractures and sedimentary bedding (or stratigraphic slope) at all scales. However, modern karst experiences multi-stage histories beyond a single evolutionary cycle. Shunbei region located in the low part of Tabei slope extensively developed strike-slip faults, having similar favorable conditions with modern karst. Therefore, the basic development laws and model of modern karst can be used as key analogs to interpret the formation mechanism of "fault-controlled paleokarst" reservoirs. The new interpretation that paleokarst reservoirs at 0~450 m are the results of the collapse-coalesce of phreatic passages is more persuasive than previous views of breccia voids. The finding that large-scale paleocave passages expand toward fractures and stratigraphic slopes guides the future designs of vertical and lateral trajectories. This study offers a good template for "fault-controlled paleokarst" reservoirs exploration using modern karst analogs worldwide.

Theme 1. Continental carbonates, karst and cave deposits

General Session

Oral presentation

The paleo-karst characteristics of Carboniferous KT-I formation in the eastern margin of Pre-Caspian Basin

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The Pre-Caspian basin is one of the largest oil and gas bearing basins in the world, and the Carboniferous Carbonate reservoirs of KT-I formation in the eastern margin are the main reservoirs. The most favorable reservoir are dissolved dolomite, and distributed on the top of the KT-I layer. In recent years, many drillings and 3D seismic acquisition have been carried out in M block located at the eastern margin of the Pre-Caspian basin. Paleo-karst systems have been identified in the Carboniferous carbonate rocks of the KT-I formation in M block. This study is mainly based on 3D seismic data, imaging logging data and core data. Firstly, the karst paleogeomorphology features in Carboniferous KT-I formation are mapped by layers interpretation of 3D seismic data, and then the characteristics of paleo-karst cave system are studied by using core, microscopic and logging data, and the distribution of karst cave system is described by RMS amplitude and variance attributions of seismic data. Finally, combined with the regional geological background, the controlling factors of karst system development in KT-I formation are discussed. The research shows that karst highlands, karst slopes, karst valleys and sinkholes are developed in carbonate rocks of Carboniferous KT-I formation, and different paleogeomorphology have different distribution characteristics. There are three factors that control the development of karst system in this area: First, the tectonic activities at the end of Carboniferous forming a local tectonic uplift in the eastern margin of the basin, which is high in the west and low in the east. It is good to develop the karst system for long-term exposure of carbonates in the study areas. Second, the long-term regressive cycle deposition of KT-I caused the groundwater level in the study area to drop continuously, and the dissolution above the groundwater level was strong, eventually forming a "beads-like" underground cave system in the study area. Third, the study area is an open platform deposit, and thick microcrystals and bright limestone developed, which is conducive to the formation of dissolution.

Theme 1. Continental carbonates, karst and cave deposits

General Session

Poster presentation

Naturally occuring botryoidal carbonates in a Holocene karst paleolake Prološko Blato (Dalmatia, Croatia).

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The Prološko Blato is a seasonal karst wetland in the NW part of the Imotsko polje (karst polje) in the Dalmatian hinterland. Ongoing paleolimnological research revealed the existence of Holocene paleolake sediments made of pale brown lacustrine carbonate, rich in gastropods and ostracods, that started to form at ca. 8000 cal yr BP. Multiproxy core analysis, including geochemical, sedimentological, and micropaleontological (ostracods), suggests a relatively shallow, oligotrophic lacustrine environment with continuous carbonate sedimentation until ca. 800 cal BP. Specific to this karstic paleolake is the occurrence of enigmatic botryoidal carbonates initially detected in coarser sieved fractions (>250 um) during the ostracod analysis, and confirmed via SEM analysis. In micropaleontological slides, botryoidal grains occur as plate-like forms, flat on one side and botryoidal (spherical) on the other, implying their growth on a fixed substrate. SEM analysis revealed that botryoidal grains are made of acicular crystals, similar to the needle-like aragonite, exhibiting two distinctive spherulitic forms: a) spherules made of needles radially spreading from the central point outwards, and b) spherules made of needles radially arranged around a circular void. This potentially implies the same formation process, but different stages of development of needle-like crystals. Botryoidal carbonates are numerous in specific samples throughout the paleolake record, which could possibly be used as a proxy for paleoenvironmental interpretation. However, their origin (organic vs. inorganic, diagenetic) and environmental conditions necessary for their formation remain to be investigated.

Theme 1. Continental carbonates, karst and cave deposits

General Session

Poster presentation

Palaeoenvironmental reconstruction of the lacustrine–palustrine record of Peña Adrian section, Upper Miocene (Miranda–Trebiño basin, N Spain)

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Palustrine–lacustrine carbonates are common features in the upper Eocene to Miocene continental series from the SW Pyrenees. They occur as sequences of cyclical limestone–marl alternations with minor coal and evaporites, infilling several piggy-back basins. Laterally, they interfinger with basin-margin alluvial clastics (conglomerates and sandstones) recording the active denudation of the surrounding Cretaceous–Paleogene uplands. A humid (sub)tropical to temperate climate prevailed in the area during the Paleogene and Neogene, punctuated by semiarid phases. This work focusses on the paleoenvironmental analysis of the upper Miocene lacustrine deposits from Peña Adrian (Miranda–Trebiño basin). This succession represents the last filling stage of the basin, previously to enhanced river incision since the Miocene–Pliocene onwards.

The succession, up to 60 m thick, consists of alluvial detrital deposits grading to well-stratified limestone–marlstones. Gastropods, charophytes and ostracods abound in these carbonate facies. Three distinct units are differentiated in the carbonate sequence. Unit 1 (12 m) consists of wackestone–mudstones with sparse gastropods and charophytes, forming m-thick cycles capped by pedogenic features (rhizoliths). They represent broad shallow vegetated areas affected by episodic subaerial exposure during the initial lake development. Unit 2 (20 m) is made of bioclastic wackestone–packstones very rich in small and large gastropods, eventually forming grainstone coquinas. They exhibit persistent internal lamination and, less commonly, cross bedding. They represent the stage of maximum lake expansion and full open conditions. Finally, Unit 3 (8 m) consists of massive mudstone–wackestones with sparse gastropods and charophytes (usually preserved as molds), with abundant root traces and pedogenesis. The vertical facies succession draws a complete cycle of lake expansion and retreat, culminating with overfilling and final emersion. Variations in the preservation potential of bioclastic components (i.e. gastropod shells) likely evidence significant changes in lake water chemistry during lake development and/or in diagenetic conditions during early burial stages.

Theme 1. Continental carbonates, karst and cave deposits

General Session

Poster presentation

Speleothems and speleogenesis of Don Juan Cave (Jalance, SE Spain)

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We provide a first integrated study of Don Juan Cave (Jalance, Valencia) based on speleothem characterization, cave mapping as well as environmental, hydrochemical and climatic monitorization. Don Juan is an exceptional karstic site due to its particular speleogenesis and its speleothem record. Although it is a touristic cave, it shows low antropogenic disturbance. The cave is located in the Iberian Ranges, in an area characterized by Mediterranean climate. It is hosted by a thick carbonate breccia unit that corresponds to a Neogene alluvial fan. It was formed by carbonate dissolution along active fractures together with piping of unconsolidated materials and collapse of blocks. The combination of these processes generated a large dome-shaped room (more than 65 m long and 20 m high) that, on its floor, accumulates large fallen blocks covered by speleothems. Around this main room, several subhorizontal and vertical passages occur and show different environmental conditions. Don Juan is being intensively monitored. Temperature averages 15°C, although different sectors can be differentiated based on their thermal behaviour and microclimatic characteristics. Relative humidity is always high but variable in space and time. Permanent dripping (i.e., through the year) is limited to inner galleries with RH close to 100%. The cave shows diverse and abundant calcite speleothems such as flowstones, columns, stalagmites, stalactites, coralloids or helictites. The concentration of coralloids and helictites along the westernmost walls of the cave is probably related with significant cave ventilation. Besides calcite speleothems, other features such as moonmilk and boxwork are also present. Although the speleothems are well preserved, we recognize speleothem alteration/corrosion in some sites. Interestingly, different types of patinas related to bat guano stain widespread areas of the cave. Speleothem growth is very scarce in the cave at the present time and probably limited to soda straws and incipient stalagmites of some recondite small galleries. Absolute ages obtained for Don Juan stalagmites indicate high speleothem growth during glacial intervals of the Pleistocene, but very limited during the Holocene and previous interglacial periods.

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Theme 1. Continental carbonates, karst and cave deposits

General Session

Poster presentation

Dedolomite as cave wall rock

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Below the Vrh Sv. Treh Kraljev hill in central Slovenia there are three caves ranging from 300 to 1000 m in length that show a ramiform and/or maze-like pattern and other evidence indicating their possible hypogene origin. The wall rock of the Mravljetovo brezno v Gošarjevih rupah cave consists mostly of a yellowish to reddish-brown calcareous deposit in an otherwise grey dolomite formation of Middle Triassic age. Mineralogical characteristics show that the yellowish to reddish-brown material consists mainly of calcite, while the colour comes from small amounts of iron hydroxides. Petrographically, several textural groups of calcite crystals can be distinguished, indicating replacement of dolomite, but also precipitation/resedimentation in open fissures and cavities formed by dissolution of dolomite. Calcite is thought to have been formed by dedolomitization (dolomite calcitization or recalcitization) of the host dolostone as a result of interaction between limestone, dolomite, and Ca-sulphate rocks via fluids in the phreatic zone. Based on oxygen and carbon isotope values, it is hypothesised that dedolomite precipitated from low-temperature aerobic meteoric water, which was recharging from areas covered with C3 plants. Whether dedolomitization predates or postdates the major speleogenesis is still not completely clear but the cave was altered and possibly significantly enlarged in the epiphreatic zone (perched conduits with clastic sediments) and in the vadose zone (shafts with active dripping water, ceiling channels formed by condensation corrosion, secondary cave minerals, e.g., gypsum, hydromagnesite, aragonite, dolomite, and phosphates such as cattiite). There are three boreholes in the area, several hundred metres deep, which intersect, among other rocks, the Upper Permian and the Lower Triassic evaporite horizon and, unlike the normal meteoric waters from some karst springs, discharging sulphate water. Chemical analyses of the water emerging from the boreholes indicate that dedolomitization is still on-going process below the surface.

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Theme 1. Continental carbonates, karst and cave deposits

General Session

Poster presentation

Anatomy and stacking pattern of palustrine-dominated carbonate parasequences (Thanetian–Ypresian, SE France): insights from carbonate petrography associated with aerial photogrammetry

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The Arc Basin is an E–W oriented depression, located in southeastern France, in which marine, lagoon, lacustrine, fluvial, palustrine and pedogenic sedimentary deposits were formed from the Upper Cretaceous (Santonian) to the Middle Eocene (Lutetian). This research covers the sedimentological and stratigraphical analyses of the outcrops of “La Barre du Cengle” cliff in which Thanetian/Ypresian limestones (Saint-Marc limestone) are exposed with thicknesses ranging from 20 to 35 m. The Cengle plateau is located south of the Sainte-Victoire Mountain, about 15 km east of the city of Aix-en-Provence. It is elliptical in shape and is 7 km long, east to west, and 3 km transversely. Its average altitude is around 500 m. With the aim of lithofaciological characterization of the studied area, samples were collected in four vertical stratigraphic logs measured at 1:40 scale. “La Barre du Cengle” consists of greyish, beige, and pinkish limestones which have been deposited in a lacustrine/palustrine environment. Deposits from this sedimentary interval were repeatedly subjected to subaerial exposure and are organized into decimeter to meter-scale parasequences. The facies comprise densely packed dark micrite mudstone and bioclastic wackestone/packstone with massive, brecciated, nodular or granular textures. The main bioclast observed correspond to reworked fragments of prismatic calcitic crystals from microcodium aggregates. Well-preserved rosettes and lamellar aggregates of microcodium have been identified in fractures/cracks. Fragments of charophytes and shells of ostracods, gastropods and bivalves complete the fossil assemblage seen in the thin sections. Subaerial exposure features like cracking, brecciation, root traces, nodulation, coated grains, pseudomicrokarst and grainification are present at different intensities. These features indicate different stages in the pedogenetic evolution and allowed the elaboration of an exposure index. The exposure index allowed the understanding of vertical and horizontal lithofaciological variation in the studied sedimentary succession. The main exposure surfaces as well as the lateral changes in lithofacies could be traced on the cliff in virtual models of outcrops generated by aerial photogrammetry acquired by UAV (unmanned aerial vehicle).

Theme 2. Shallow-marine carbonate depositional systems and carbonate platforms

Special Session 2.1. Biogeodynamics of Mesozoic marine carbonate depositional systems

Oral presentation

Basin to reef transition in the Middle Triassic Northwestern Croatian rift related basin (NCTRB)

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In NW Croatia Middle Triassic volcano-sedimentary successions were deposited on the passive continental margin during a period of extensional tectonic related to the Neotethyan rifting. The studied succession in Očura Quarry on Ivanščica Mt is 34 m thick section, divided into three parts. The lower part is composed of dominantly basaltic rocks. In the basal part glomeroporpyric basalt is overlaid by basaltic autoclastite and peperite. The middle part is composed of cm–dm thick irregularly and wavy bedded calcarenites, in places coarsening upward. Carbonate lithoclasts are mostly micritic limestones with bioclasts. Basaltic lithoclasts are less common, one with the porphyric to glomeroporphiric texture, similar to basalt from the lower part; and the other type completely hyaline. There are also thin layers of biomicrites with filaments and radiolarians, thin layers of volcaniclastics, and a thick breccia interval. The upper part is composed of extremely unsorted breccia with slump-texture. Clasts of limestones, calcarenites, and subordinary basalts are supported by fine grained matrix of carbonate and basaltic particles. Within breccia there are abundant framestone clasts containing complex reef community, dominating of sponge *Celyphia zoldana*, with other microorganisms of uncertain taxonomy *Plexoramea cerebriformis* and *Olangocoelia otti*, and others. The investigated section represents sedimentation in the deeper marine environment near the steep edge of the carbonate platform that prograde over it. Basalts found at the base of the section represent submarine effusions, and their fragmentation and reworking. A thick interval of calcarenites with basaltic lithoclasts is formed by shedding of the carbonate material from the nearby platform to the pelagic/basinal areas, indicated by the pelagic limestone interlayers. Chaotic breccia with meter sized fragments of reefal limestones indicates a more proximal position regarding to the shallow marine area from which these clasts were derived. Slump texture emphasizes gravitational processes. The general trend of coarsening upward, as well as the predominance of the framestone clasts in the breccias imply the progradation of the platform over the basinal areas. Similar successions have been described from the neighbouring area.

Theme 2. Shallow-marine carbonate depositional systems and carbonate platforms

Special Session 2.1. Biogeodynamics of Mesozoic marine carbonate depositional systems

Oral presentation

Astronomical pacing of flint beds in the European chalk sea (type-Maastrichtian, Upper Cretaceous)

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Upper Cretaceous chalk deposits, commonly containing flint nodules and bands, are found all over north-west Europe. The question still stands, however, how these flints are formed and whether the pacing of these often rhythmically distributed flint beds can be astronomically controlled. To address this question, we investigated a Maastrichtian chalk succession near Hallembaye (BE) in the type-area around Maastricht (NL). The Hallembaye section is characterized by a gradual change in lithology varying from greyish chalk with rare occurrences of flint nodules towards more pure, whitish chalk with clearly expressed flint bands. Micro X-Ray Fluorescence measurements were carried out on powdered chalk samples to determine their elemental composition. 'Flint Scores (FS)' were attributed to quantify the distribution of flints in function of the stratigraphic height. Using an integrated stratigraphic approach, we performed a cyclostratigraphic study to evaluate a potential astronomical imprint. The Ti/Al signal, a diagenesis-resistant proxy reflecting changes in the composition of detrital influx or the provenance thereof, reveals short-scale fluctuations superimposed on a gradually decreasing trend. Time-series and spectral analyses of the Ti/Al signal reveal a dominant 40 kyr obliquity component with its 173 kyr modulation, as well as a weaker precession–eccentricity signal. Analysis of the FS equally suggests an astronomical pacing of the flint layers. We tune the FS record to the stable 173 kyr and 405 kyr astronomical cycles to construct a high-resolution age model in absolute time, complementary to a floating 40 kyr obliquity time scale. The exact mechanisms of the flint formation and its astronomical pacing remains subject of further research but seem most likely to be linked to changes in clay content. Possibly, variations in the influx of detrital material could have influenced local redox conditions as well as the paleoproductivity in the water column.

Theme 2. Shallow-marine carbonate depositional systems and carbonate platforms

Special Session 2.1. Biogeodynamics of Mesozoic marine carbonate depositional systems

Oral presentation

Biotic and carbon cycle perturbations during OAE1a along the NE Arabian Plate, Zagros Mountains

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The Aptian greenhouse Earth underwent profound climatic and environmental changes from the early Aptian (super)greenhouse with the deposition of organic-rich sediments corresponding to the OAE 1a (Selli Event, ~120 Ma), followed by the late Aptian cooling trend, to gradual warming in the latest Aptian. These extreme changes, driven by the perturbations in the global carbon cycle, also included fluctuations in ocean fertility, carbonate platform inception/drowning, and biotic shifts/crises. To track $\delta^{13}C$ fluctuations and environmental and biotic response to the OAE1a along the NE Arabian Plate, we logged bed-by-bed two continuous mountain-side sections of the Kazhdumi Intrashelf Basin, Zagros Mts., near Pir Sabz and Dareh Sefid (67 m and 265 m thick, respectively). Both sections are characterized by hemipelagic to shallow-marine deposition without hiatuses and limited influence of meteoric diagenesis. The onset of the OAE1a is marked by an abrupt increase in the planktic foraminiferal and radiolarian abundance, and a lithological change from ostreid-dominated shallow-marine carbonates with benthic foraminifera (*Palorbitolina lenticularis*, *Choffatella decipiens*) to deeper-water limestone and organic-rich shale. The bulk of the OAE1a-corresponding deposits includes the Radiolarian Flood Zone, which is the genuine intrashelf basin and regional equivalent of the OAE1a. The early post-OAE1a deposits are represented by clayey limestone with chert bands alternating with shales and marls, which are conformably overlain by the upper Aptian *Mesorbitolina*-rich shallow open-marine to lagoonal limestone, and capped by a well-developed, regional unconformity due to a major sea-level fall. The comparison of the $\delta^{13}C$ stratigraphy between the Kazhdumi Intrashelf Basin and the selected Tethyan locations shows similar trends and excursions across the different settings (pelagic, hemipelagic, shallow marine). This suggests that the fluctuations were driven by the changes in the global carbon cycle, albeit modified by regional environmental changes and diagenesis. Results of this study stress the importance of shallow carbonate-dominant intrashelf basin successions as faithful recorders of carbon-isotope, biotic, and sea-level oscillations during global oceanic perturbations.

Theme 2. Shallow-marine carbonate depositional systems and carbonate platforms

Special Session 2.1. Biogeodynamics of Mesozoic marine carbonate depositional systems

Oral presentation

Bajocian coral reefs: likely a global reef growth event

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Currently, the Middle Jurassic is not considered favourable for coral reef growth. During this time, most reef builders were still expected to recover from mass extinction events of the Late Triassic and Early Jurassic, as well as from subsequent global perturbations of the carbon cycle and increased continental weathering. Here we present a recently discovered coral reef platform in subsurface of northern Switzerland, informally called the "Herrenwis Unit". Data comes from the Bülach-1 and Stadel-3 boreholes in the Nördlich Lägern region, displaying well-preserved corals. The reef consists of a variety of species, but five coral genera account for over ninety percent of the total number of identified coral specimens. The assessment of the growth features and orientation of the corals, the presence of a microbialite crust around some corals and the paucity of transport features indicate that most corals are in growth position. Growth bands found in some specimens indicate a growth rate comparable to that of coeval corals (2 mm/year). This reef is typical of the Bajocian, based on coral diversity and abundance. Due to local current mechanics, a small palaeohigh had likely formed out in the underlying formation. This palaeohigh, perhaps coupled with favourable palaeoclimate, allowed corals to start growing in patch reefs and later coalesced to form a small reefal platform. The characterisation of this newly identified reef, dated to the Bajocian by means of palynology, is the starting point to explore further coral reef growth at regional and global scales. Similar coral reefs across the Burgundy Platform in eastern France were also dated using palynology. The results confirmed that coral reefs in the Burgundy Platform were coeval with their counterparts in Switzerland. By updating previous literature reviews and re-evaluating the coral assemblages of known and recently reported Middle Jurassic reefs, we hypothesise a global coral reef event in the Early Bajocian. An additional outcome of the compilation is that most of these Bajocian reef sites are distributed along a hypothetical palaeogeographic belt on the northern margin of the Tethys. The rarity of low-latitude reefs is not yet fully elucidated but seems to support the hypothesis of high temperatures in low latitudes during the Middle Jurassic.

Theme 2. Shallow-marine carbonate depositional systems and carbonate platforms

Special Session 2.1. Biogeodynamics of Mesozoic marine carbonate depositional systems

Keynote lecture

Biogeodynamics of Cretaceous marine carbonate production

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We have compiled stratigraphic ranges of genera of the main planktonic and benthic carbonate producers of the Cretaceous, such as calcareous nannofossils, calcispheres, planktonic foraminifers, larger benthic foraminifers, corals and rudists bivalves, and species of dasycladalean green algae. The observed diversity patterns are compared with independently raised proxy data of Cretaceous climate and seawater chemistry to elucidate the effect of environmental change on carbonate production and sedimentation. Diversity patterns of calcareous nannofossils, calcispheres, planktonic foraminifers and corals trace the evolution of Cretaceous sea-level, while those of dasycladalean algae, larger benthic foraminifers, corals and rudist bivalves document significant reductions at the level of oceanic anoxic events (OAEs). These general patterns appear to be unrelated to the autecology of the taxa investigated. Aragonitic or aragonite-dominated benthic carbonate producers are most affected during extinction events related to OAEs, and a general trend of decreasing aragonite dominance throughout the Cretaceous has been observed. The demise of aragonitic or aragonite-dominated carbonate producers at OAE1a (early Aptian) and OAE2 (Cenomanian–Turonian boundary interval) may be related to short episodes of reduced seawater carbonate-saturation caused by short-lived injections of CO_2 from large igneous provinces that initiated OAEs. The expansion of suitable habitats during episodes of high sea level and high temperatures is thought to have controlled diversity patterns of calcareous nannofossils, planktonic foraminifers, and corals rather than changes in seawater chemistry. An increase in the relative number of azooxanthellate coral genera following OAE1a and OAE2 suggests a disruption of photosymbiosis due to high temperatures, although the relative numbers of azooxanthellate genera continued to increase during the Late Cretaceous, when global temperatures declined. Due to the short residence time of major nutrients in seawater, these may have affected carbonate-producing ecosystems regionally, but not on a global scale. The recent pattern of benthic carbonate production being highest in oligotrophic environments cannot confidently be extrapolated to the Cretaceous.

Theme 2. Shallow-marine carbonate depositional systems and carbonate platforms

General Session

Oral presentation

Integration of forward stratigraphic modeling for characterizing a reefal carbonate buildup within the Middle East

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In this study, we are highlighting the importance of creating sequence stratigraphic frameworks and their integration with predictive Forward Stratigraphic Modeling. The reservoir represents a classical Reefal buildup along with its platform. A geological model was prepared by integrating Seismic Inversion which helped in capturing some of the reservoir quality trends of the Reefal Buildup facies and the platform facies however, the Seismic Inversion results could not give a valuable insight into the smaller parasequences and higher resolution details on the architecture and morphology of the Reefal buildup as observed on the well data and the indications of discontinuous facies across the field between the multiple carbonate buildups in the vicinity as indicated from the dynamic data. To solve this challenge a forward stratigraphic modeling approach was used where in Step 1 a detailed sequence stratigraphic framework was constructed using the available well data and seismic data along with the results of the seismic inversion. In Step 2 Integration of the Sequence Stratigraphic Framework with the predictive forward stratigraphic modeling approach was used to build a more representative forward model. The forward stratigraphic model predicted the distribution of the Carbonate facies, the best Reefal facies were distributed near the main Reefal buildup which represented the core and where the core wells are drilled and currently producing. The forward stratigraphic model also predicted another smaller Southern Reefal buildup within the acreage which pointed toward the presence of another possible area for future appraisal and concentration of upcoming wells. The forward stratigraphic model showed two remarkable differences to the previous geological model. The first difference was that the forward model simulation predicted a higher connected volume around the Frontal producing part of the Reefal buildup and the second difference was it showed the presence of good quality facies mainly the core Reefal part around the producing wells compared to high reservoir quality (RQ) variation from the seismic inversion results.

Theme 2. Shallow-marine carbonate depositional systems and carbonate platforms

General Session

Oral presentation

Geochemical analyses and the impact of bioturbation in hardground formation: the Abu Dhabi coastal sabkha

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Sabkha, which means salt flat in Arabic, is a term used to describe the evaporitic environments associated with the landward portion of low angle, homoclinal ramps. Al Qantur Lagoon is an intertidal zone seaward of the supratidal sabkha where shallow carbonate hardgrounds are observed alongside burrowing organisms, microbial mat communities and microfauna. The physico-chemical constraints on hardground formation are poorly understood, with current research encouraging further geochemical and biologic analyses. The objective of this study is to identify the role infauna may have on early diagenesis and subsequent hardground formation. Four study sites along a 600 m transect perpendicular to the shoreline were selected based upon sedimentary textures and changes in bioturbation. Each location was cored and sampled at cm-scale intervals for pore waters. Sediment cores were imaged using an x-ray and a CT scanner to identify biogenic structures. Cores were also sampled for geochemical analyses. The transect from a microbial bindstone in the upper intertidal zone to a bioturbated peloidal grainstone in the lower intertidal zone revealed that crustacean burrowers are more abundant in seaward portions of the lagoon and polychaete burrowers are concentrated in the middle-intertidal zone. Pore waters within invertebrate burrows are less saline than sediment pore waters (~70 g/L TDS within burrows versus 90–210 g/L TDS within pore water). This suggests the burrows provide means of altering solute distribution and transport by producing and irrigating permeability pathways. Firmgrounds correlate to a decrease in burrowing along the transect, suggesting that bioturbation inhibits early diagenetic processes. Furthermore, stable isotopes from sampled sediment cores become lighter from a seaward to landward position ($\delta^{13}C$(VPDB): 5.6–3.5; $\delta^{18}O$(VPDB): 4.0–0.7, respectively), indicating a landward increase in diagenesis, where far less bioturbation is observed. Sub-sampled hardgrounds are isotopically lighter on the upper and lower edges of the hardground than the center. This is best ascribed to hardground formation occurring from the outside-in. The range in stable isotope data observed in both the hardgrounds and the sediment cores represent variations in microbial activity, evaporation, and diagenesis.

Theme 2. Shallow-marine carbonate depositional systems and carbonate platforms

General Session

Oral presentation

Larger benthic foraminifera as an important tool for palaeoenvironmental interpretation of Campanian inner platform settings, island of Brač (Croatia)

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The informal group of larger benthic foraminifera (LBF) generally exhibits a high potential for biostratigraphy, palaeoenvironmental interpretations, and palaeobiogeographic comparisons in Tethys, especially during the Cretaceous greenhouse period.

Late Cretaceous Global Community Maturation Cycle (GCMC) encompasses the Turonian–Maastrichtian interval representing a special period of increasing diversity of LBF in shallow water settings. The LBF suffered from the palaeoenvironmental distributions associated with the Cenomanian–Turonian boundary OAE2 event leading to the almost complete extinction. During the Coniacian–Santonian, LBF already underwent a remarkable diversification in a wider area of Tethys associated with widely distributed extensive platform carbonate evolution. From Campanian inner platform facies, numerous taxa of LBF have been reported from Spain, Greece and Croatian island of Brač. Shallow-marine carbonate platform deposition on Brač represents an essential contribution to understanding Late Cretaceous evolution of one of the best preserved Mesozoic Perimediterranean carbonate platforms with especially favourable conditions for the development of LFB in Campanian (Gornji Humac and Pučišća fms) as a consequence of gradual progradation of platform environments over hemipelagic Dol fm resulted in diachronous upper boundary. Platform progradation resulted in establishment of shallow-marine environments progressively covering larger areas until the final covering of the Brač Marbles mb: Rasotica and Lovrečina mbrs of Pučišća fm that merged with the Gornji Humac fm. Such complexity of very different lithofacies enabled Campanian assemblages to be most diversified.

Ongoing studies have revealed additional four new taxa (one new genus) of LBF described from lower–middle Campanian carbonates of the island of Brač, Croatia, two of them are also reported from time-equivalent strata of the Gavrovo–Tripolitza Platform (SW Greece), while providing further evidence for the pronounced Campanian diversification within the Late Cretaceous GCMC of AdCP.

Theme 2. Shallow-marine carbonate depositional systems and carbonate platforms

General Session

Oral presentation

Sediments and facies of modern warm-water carbonate platforms: a global perspective

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A total of 752 surface sediment samples collected on carbonate platforms in the western Atlantic, the central and eastern Indian Ocean, and the south and west Pacific Ocean, as well as the Persian Gulf have been re-visited. Grain composition, texture, mineralogy, and geochemistry have been analyzed in a quantitative and statistical manner. Fragments of coral skeletons, calcareous algae (Halimeda, corallines), mollusk shells, and non-skeletal grains (predominantly peloids) are the most abundant constituent grains. Coralgal, grain-supported textures are common at platform margins whereas mud- and grain-supported textures with mollusks and non-skeletal grains are ubiquitous in platform interiors. Multivariate statistics have been used to discern up to ten facies. There is a statistically significant correlation between the amount of fines ('mud') and water depth, i.e., depositional energy, however, different facies may be found virtually at all depths thereby challenging intuitive and long-standing concepts of sediment distribution. Aragonite and high-magnesium calcite are the most common carbonate phases. Stable isotopes of oxygen and carbon ($\delta^{18}O$, $\delta^{13}C$) of bulk samples exhibit wide ranges and appear to be rather controlled by general location than by depositonal environment within carbonate platforms. Western Atlantic platform samples show the highest $\delta^{13}C$ and those from the Persian Gulf and the eastern Indian Ocean the highest $\delta^{18}O$ values. This might be a consequence of the observation that the former usually contain higher amounts of non-skeletal grains and Halimeda; the latter are likely influenced by elevated salinity in surface waters. Coral fragments appear to be more abundant in Indo–Pacific as compared to Atlantic platform sediments. With regard to the so-called 'oolite problem', it seems that non-skeletal grains are found prefentially where carbonate supersaturation is high and skeletal production and sedimentation rate low; these preconditions are fulfilled not only in the classical western Atlantic locations, but also in certain areas of the south Pacific. The 'mud problem' is still controversially discussed, but it appears that biogenic (detrital) origins predominate over abiogenic origins from a global perspective.

Theme 2. Shallow-marine carbonate depositional systems and carbonate platforms

General Session

Oral presentation

Combined architectural-element and microfacies analyses in carbonate sedimentology: the intra-basin shoal complex of the Lower Muschelkalk (Rüdersdorf Formation, Anisian)

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The layer-cake carbonates of the epeiric Lower Muschelkalk (Anisian) are devoid of large-scale stratal pattern architectures, e. g. steep clinoforms of a progradational platform slope. This resulted in a simplified approach in facies analysis, in which results of microfacies analysis (microscale) are used directly to conclude on depositional models (macroscale). In the geology of fluvial deposits, architectural elements are routinely used to describe the geometries of sedimentary bodies (mesoscale) in their genetic context. A conceptual implementation of architectural-element analysis as a consistent intermediate step in carbonate facies analysis is still missing. The intra-basin shoal system of the Anisian Rüdersdorf Formation shows a complex pattern of fore- to backshoal facies interfingering with offshore facies of an epeiric Inland Sea. Thus, it represents an ideal case study on depositional architectures of epeiric carbonates. Our data are based on a detailed bed-by-bed outcrop and core study in greater Berlin including the Rüdersdorf open-pit mine to the East of Berlin. The vertical succession exposed in both outcrop and well cores shows gradual transitions from bioturbated marly limestone to thick cross-bedded oolitic grainstone lithofacies. Hardgrounds and proximal tempestites are frequently intercalated, and represent important marker beds for correlation. Local and regional correlation schemes reveal complex pattern of vertical and lateral facies shifts associated to the repeated formation, migration and drowning of an intra-basin shoal system. Vertically stacked carbonate sand bars and carbonate sand waves represent the shoal top and shoal fringe, respectively. Multi-storey sheet-like channels and individual sheet-like channels characterize gravity flow deposits of the medium- to low-energy offshore transition zone, with decreasing internal complexity of individual beds in down-current direction. Simple sheets and simple channels are associated with redeposition in the mud-dominated offshore zone. Vertical trends from simple to complex architectural elements are in line with the progradational pattern of the Rüdersdorf Formation derived from classical microfacies analysis, but enable more detailed reconstructions of the physical bedding processes.

Theme 2. Shallow-marine carbonate depositional systems and carbonate platforms

General Session

Oral presentation

Revision of the Upper Cretaceous to Danian stratigraphy of the upper Chalk Group of South Limburg, the Netherlands

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The Upper Cretaceous to Danian Chalk Group of South Limburg constitutes an important aquifer. Groundwater quality in this aquifer has declined in recent years due to a high concentration of nitrate. Current geological models, required to manage the aquifer appropriately, cannot accurately simulate groundwater flow. This inability is partially due to inadequate facies characterization and lithostratigraphic subdivision and correlation of the reservoir unit. Existing stratigraphic subdivisions are essentially biostratigraphic, rather than lithostratigraphic, and correlations are unlikely to be representative of the subsurface architecture of the aquifer. Additionally, current 'litho'stratigraphic subdivisions are based on scarce outcrops and are hard to identify in boreholes and track in the subsurface. The upshot of these problems is poor understanding of the architecture of the aquifer, its subsurface distribution, and its properties, such as porosity and permeability. For this project, we revisited nine outcrops in South Limburg and studied a new borehole in South Limburg (Eys 01) and an existing borehole in northeast Flanders (Molenbeersel); we carried out a litho- and microfacies analysis of the upper Chalk Group. Despite the name of the group, the Upper Cretaceous to Danian of South Limburg consists of rather coarse mixed carbonate–siliciclastic sedimentary rocks. Lithological heterogeneity is present on several scales and is due to both primary facies variability and diagenesis. Here, we present a revision of the lithostratigraphy of the upper Chalk Group. Our results are expected to improve correlation between boreholes and outcrops and eventually improve groundwater flow simulations required to appropriately manage the aquifer.

Theme 2. Shallow-marine carbonate depositional systems and carbonate platforms

General Session

Oral presentation

Deciphering the drivers of suspended sediment atop the Great Bahama Bank

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Wind, tides, and waves dictate facies heterogeneity by lofting, transporting, and depositing sediment. Hence, carbonate platforms are often partitioned according to these drivers and terms such as ‘storm-dominated’ platforms and ‘wave-dominated’ margins are part of the common vernacular. Daily satellite observations of the Great Bahama Bank (GBB) allow us to investigate these drivers and their sedimentological responses in real time. We compare daily observations of total suspended sediment acquired by MODIS to contemporaneous measurements of waves, tides, and wind using a machine learning framework. Despite the GBB experiencing extreme storms, we show that 5–10× more sediment is set in motion annually during fair-weather conditions, which occur for 98% of the days in any given year. Unlike storm-induced transport, which is induced by high wind, our data emphasize the importance of tidal flow and waves in moving sediment on fair-weather days, though the importance of these drivers varies according to location on the platform and the season. Contrary to expectation, tides are the dominant driver of sediment movement across the windward side of GBB because aeolianite islands mantle this margin, serving to focus tidal energy. By contrast, for the leeward margin, which generally lacks islands, wind and waves exert dominant control over sediment resuspension and deposition. Meanwhile, sediment movement in GBB’s interior is predominantly controlled by wind, since the influence of waves and tides dissipates with distance from the platform margin. All these controls vary by season too and winter trade winds, which blow for six months of the year, suppress the importance of tides and waves as drivers of sediment movement across the platform margin and in the platform interior. This finding emphasizes that the facies heterogeneity atop platforms situated in the subtropical trade-wind belt is controlled by a different suite of drivers, which themselves vary seasonally, than equivalent platforms in the tropics. Such differences are likely to manifest in the facies anatomy of ancient platforms as they do in the modern.

Theme 2. Shallow-marine carbonate depositional systems and carbonate platforms

General Session

Oral presentation

Fossil coral reef terraces in Southeast Asia as recorder of sea-level changes since the Pleistocene

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Coral reef terraces (CRTs), which are planar geomorphological features formed through repeated bioconstructional and erosional processes, are useful indicators of previous positions of sea level. The Last Interglacial (LIG) is often considered to be a process analog for predicted future changes for a warmer world. Analysis of sea-level indicators during this period can give us important insights about the rates of sea-level change and potential drivers of regional and global sea-level changes in the past. We previously produced a standardized database of LIG sea-level indicators in Southeast Asia. Following this work, we revisited a site in the Philippines where inferred Late Pleistocene CRTs were previously reported. In this paper, we present new geomorphic and stratigraphic data on the fossil CRTs observed in western Pangasinan, in Luzon Island, Philippines. The low-lying areas of western Pangasinan are underlain by sequences of calcareous sandstone–mudstone with minor pebbly conglomerate and tuffaceous sandstone units belonging to the Late Miocene to Early Pliocene Sta. Cruz Formation. Unconformably overlying the sandstone unit of Sta. Cruz Formation is the Plio–Pleistocene Bolinao Limestone, and a sequence of CRTs is cut onto it. Based on our surveys and analysis of digital elevation models, we identified distinct levels of coral reef terraces which may correspond to several episodes of RSL change since the Pleistocene. We designated the lowest elevation terrace (at 3–4 m amsl) to be Holocene based on radiocarbon ages (~6.2–5.3 ka cal BP) of fossil corals. Two *Tridacna* spp. shells collected at 3–8 m amsl elevation yielded ages of ~45.5–42.8 ka cal BP. We were not able to find pristine fossil coral samples at elevations of 5 to 160 m amsl. Based on these ages, we have provided evidence of older than Holocene terraces in the region although the age of the highest terrace (at 160 m amsl) is yet to be constrained. While analysis of coral reef terraces is important in understanding RSL changes in a region, the difficulty of finding dateable materials makes our work more challenging. Despite this, we hope that our data will be useful in further understanding the different drivers of past sea-level changes in SE Asia providing necessary geologic baseline data for projections of sea-level change in the future.

Theme 2. Shallow-marine carbonate depositional systems and carbonate platforms

General Session

Oral presentation

Miocene shallow-water tropical transitional carbonate systems in the Caribbean affected by adverse photic zone conditions: characteristics and how they formed

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Tropical shallow-water transitional carbonate systems (TTCS) form when the photic zone is perturbed, commonly due to excess nutrients, turbidity, and cool water, which affects biotic composition. Although these systems are found throughout the rock record, they remain poorly understood. During the Miocene, regional upwelling in the Caribbean adversely affected the photic zone and TTCS formed throughout the Caribbean, providing an opportunity to further understand these systems. The facies in the TTCS are characterized by heterozoans and some photozoans, mostly large benthic foraminifera (LBF), corals and red algae that can tolerate adverse photic-zone conditions. A representative example comes from a well-exposed Miocene (Langhian–Tortonian, ca. 15–10 Ma) TTCS ramp developed in Puerto Rico. Overall, facies were deposited in seagrass environments with varying low- to high-energy conditions and local development of shoals and patchy coral reefs. Sea-level fluctuations resulted in formation of three sequences, each characterized by heterozoans, LBF, and red algae in basal portions deposited during sea-level rises, with photozoan coral facies only occurring in upper portions deposited during late highstands and falls. Two sequence boundaries (dated at 12.3 Ma and 11.1 Ma) reflect sea level falls that correlate to time-equivalent unconformities in other well-dated Caribbean areas and to sea-level lows on eustatic curves, thereby suggesting a global signature. Sea-level fluctuations and regional tectonism resulted in opening and closing of the Caribbean and Pacific connection (Central American Seaway) at various times, which may be reflected in the stratigraphy. Times of restricted connection during sea-level falls and lows resulted in reduced nutrients and upwelling, which may have been more conducive to coral development. Combining different scales of data, ranging from sequence stratigraphic frameworks and geometries, construction of quantitative relative sea-level curves, determining ages, and identifying biotic components to genus and species levels, can aid in recognition and understanding of environments and developmental controls for TTCS.

Theme 2. Shallow-marine carbonate depositional systems and carbonate platforms

General Session

Oral presentation

Origin of low-frequency sedimentary cycles in the Middle Magdalena Valley Basin of Colombia: a 30 Ma sedimentary archive of the Upper Cretaceous orbital beat

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The Cretaceous of the Middle Magdalena Valley Basin (MMVB) of Colombia is one of the most complete sedimentary sequences in the world. The sequences in this basin are characterized by sedimentary cycles that show different hierarchical ranks, ranging in thickness from multimetric to centimetric, and in age from million to thousands of years. Unlike other epicontinental seas that existed during the Cretaceous, the MMVB sequence was deposited adjacent to a passive-like margin and thus contains a sedimentary archive that was mainly driven by sea-level fluctuations. The lowest-frequency sedimentary cycles (multi-million year) are represented by the upper Cenomanian–middle Turonian Salada–Pujamana supersequence, and the upper Turonian–middle Campanian Galembo–La Renta supersequence. For the former, organic-rich mudstones and wackstones of foraminifera and fish remains are present at the base of the Salada Formation, and represent a high sea level on a carbonate-dominated anoxic ramp. This formation gives way to a siliciclastic unit known as the Pujamana Formation, which evidences the progradation of the proximal facies onto the basinal area and a reoxygenation of the anoxic substrate. This unit, with thickness of 150–200 meters, was deposited in about 1.5 Ma, suggesting that mudstones in this formation were laid down by hyperpycnal flows associated to a deltaic environment, rather than by decantation in a low-energy environment. The second sequence is characterized at the base by a new flooding of the ramp with pelagic allochems and low-detrital input, leading to the deposition of mudstones and wackstones of foraminifera (i.e., Galembo Formation). This unit passes upwards into a phosphate-dominated unit (the La Renta Formation) that consists of grainstones and packstones of pellets, fish remains, and benthic foraminifera. The transition from the Galembo to the La Renta Formation is consistent with a fall of the sea level, high marine productivity, and a basin-scale amelioration of anoxic conditions driven by storm activity. In the absence of local tectonism and given the stacking pattern of the units in the MMVB, we argue that these supersequences record sea-level variations forced by long-period astronomical cycles and track the orbital beat of the tropical ocean during a hothouse world.

Theme 2. Shallow-marine carbonate depositional systems and carbonate platforms

General Session

Oral presentation

Low scleractinian coral diversity in the incipient Red Sea (Burdigalian, Saudi Arabia)

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In the Cenozoic, temperatures and pCO_2 dropped from high levels of the late Mesozoic to present-day levels, with a plateau in the Burdigalian to Langhian (Early to Middle Miocene). It was only afterwards, during the Late Miocene, that scleractinian coral reefs developed into the euphotic ecosystems known from the present-day tropical and subtropical shallow-waters. Coral diversity peaked in the Burdigalian and declined afterwards. In contrast, scleractinian coral diversity in the Lower to Middle Miocene was low in the Red Sea that had started to open in the Oligocene and experienced its first marine incursion in the Burdigalian. Here, we report on coral diversity of Miocene reefs assigned to the Burdigalian to Langhian Wadi Waqb Member (Jabal Kibrit Formation) from outcrops exposed in the foothills behind the Red Sea coastline near Umluj, Saudi Arabia. Coral specimens found here and the records in the literature and the PaleoBiology database suggest a similarity in coral composition between Saudi Arabia, the Mediterranean, and the Arabian Gulf, but not with the Indian Ocean during the Lower to Middle Miocene. These faunistic differences are consistent with the hypothesis that there was no connection between the Red Sea and the Indian Ocean from the Early Oligocene to the Pliocene, as the south of the Red Sea area was uplifted by the Afar mantle plume, while the Red Sea was connected to the Mediterranean through the Gulf of Suez. Thus, direct exchange of marine biota with the Indian Ocean was blocked. While the coral taxa (genus level) identified in the Wadi Waqb Member of Umluj are still extant in the Red Sea, the type of buildups differs significantly. In contrast to the modern fringing reef and lagoon systems, the Burdigalian reefs are preserved as stacked mounds. This conforms with previous work on the Burdigalian in the Mediterranean that points to a mesophotic affinity of coral buildups during that time.

Theme 2. Shallow-marine carbonate depositional systems and carbonate platforms

General Session

Oral presentation

New insights on the eastern margin of the Early Jurassic Trento Platform (Southern Alps)

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Studies on carbonate platform margins of Lower Jurassic age are rare, due to the scarcity of good outcrops. The Early Jurassic Trento Carbonate Platform represents with the Calcari Grigi Group one of the major paleogeographic units of the Mesozoic Tethys, bounded by the Belluno and the Lombardian basins. While the western margin, facing the Lombardian Basin, has been already described, little is known about the eastern one, mainly due to poor stratigraphic definition and problematic accessibility of outcrops. The characteristics of the eastern platform margin are strictly controlled by tectonics and type of carbonate factory. The increase in subsidence since Late Triassic, coupled with extensional tectonics, started to define shallow water areas, dominated by subtidal and peritidal muddy carbonates, and deeper basins, such as the Belluno Basin. A mud-dominated carbonate factory developed about 500 m of carbonate cycles, until lower Sinemurian, when major environmental changes occurred. The Hettangian–Lower Sinemurian margin is not well exposed and is strongly dolomitized; tectonically controlled escarpments are present. A major switch of the carbonate factory led to a huge production of peloids and ooids, promptly shed in the surrounding basin: in the Eastern Trento Platform we recognize a 400/500 m thick wedge of Sinemurian to Pliensbachian ooidal calcarenites pinching-out towards the basin, with scattered bioconstructions made of calcareous sponges across the margin. This wedge pinches out also towards the platform interior, showing that the ooids were poorly preserved on the platform top. The preserved slope shows an angle of about 20–25°. In the Upper Pliensbachian, probably in the Margaritatus zone, the carbonate platform experienced a drowning phase, switching to encrinitic calcarenites. These encrinites are extremely thin on the platform top, but a resedimented wedge in the proximal basin highlights the position of the topographic margin. The Eastern Margin of the Trento Platform is a rare example of Lower Jurassic carbonate platform margin that can be used as a reference for coeval carbonate platform depositional systems.

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General Session

Oral presentation

Sedimentary succession with reddish polyphase infillings in the megalodontid bivalves and solution voids in Julian Alps

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At a nature-preserve protected locality in the Julian Alps (NW Slovenia), in the Pod Peski Valley, red fillings of megalodontid bivalves occur within the Upper Triassic Dachstein Limestone. Based on an optical and cathodoluminescent microscopy, and X-ray fluorescence analysis (XRF), four generations of shell infillings were recognized, some of them containing both, cement and sediment infilling sub-generations. Logging and sampling of the limestone sequence a few meters below and above the "main" layer with the above-mentioned megalodontids revealed that the limestone is characterized by solution voids similar to megalodontids. Namely, these voids are also filled with reddish multi-generation sediment with alternation of calcite cement. Adjacent neptunian dykes were studied to elucidate their impact on fillings of the last generation. Two of them, located directly on the "main" layer with red-filled megalodontids, contain planktonic foraminifera, which indicates the Middle Jurassic or younger age. The next two neptunian dykes are located just above the "main" layer, and one contains clasts with calpionellids, characteristic of the Late Jurassic / Early Cretaceous. The last dyke explored is located a few tens of meters away from the "main" layer and it is hundreds of meters long. In a few samples from this dyke Early Cretaceous planktonic foraminifera were identified. Based on microscopic analysis, the reddish sedimentary fillings are part of the complex paleokarst system that produced first three infill generations and in the last (fourth) generation we noted similarities between megalodontid fillings and neptunian dykes on the "main" bedding plane. In additionally, a Santonian–Maastrichtian sedimentary filling with globotruncanid foraminifers were discovered in the upper part of the succession in one of the solution voids.

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General Session

Oral presentation

Cave exposes three-dimensional architecture of a Middle Devonian biostrome

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During the Devonian period, reef development reached an acme in terms of carbonate production and latitudinal distribution. Here, we present stratigraphic, sedimentological and palaeoecological data from a Givetian coral–stromatoporoid biostrome exposed in three dimensions in the Klutert Cave in the northern Rhenish Slate Mountains, Germany. The short-lived (auto- to autopara-)biostrome formed during a mixed carbonate–clastic interval and is overlain by clastic units. The interval represents a regional transitional phase from predominantly argillaceous sedimentation to an actual reef-building phase. Acid digestion data indicate a high sediment influence throughout reef development, a feature that is of interest with regard to sediment-stressed reefal environments. The ca 6-km-long net of cave tunnels formed in a middle Devonian (Givetian) carbonate unit that is only about 12 m thick and that hosts the biostrome. Recently cleaned cave walls provide access to ca 26.000 sqm of rock surface. The lack of wall decorations (speleothems, flowstones) offers access to a unique level of exposed detail of the three-dimensional architecture of the reefal phase from its onset to its demise. We present evidence on the internal structure, the lateral variability and the interrelation between the main reef builders (stromatoporoids, tabulate and rugose corals).

Theme 2. Shallow-marine carbonate depositional systems and carbonate platforms

General Session

Oral presentation

Role of Metamorphic Core Complex (MCC) topography dynamic evolution during the Paleocene–Eocene Thermal Event (PETM): example of Coral Sea (PNG)

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A collisional margin with an associated foreland basin complex typically records a lateral change from the thrust to the flexural forebulge. This convergent event has a strong impact on the response of dynamic topography and basin fluid circulations. If numerous papers have discussed the flexural response of the lithosphere during this convergent event, very few articles have discussed the importance of rift inheritance. The Totalenergies's blocs (PPL589 and PPL576), localized in the northern part of the Coral Sea (PNG) system, are a nice example, where the presence of metamorphic core complex (MCC), during the rift period, have been detected through several offshore 2D lines. Based on a solid regional sequence stratigraphy picking and structural restoration sketches, we can also demonstrate the presence of remarkable Paleocene–Eocene carbonates geometries above these MMC. According to the calibration datasets from IODP–DSDP wells and other coeval analogs, seismic-scale geometries were interpreted as carbonates systems recording the Paleocene–Eocene transition. This so-called warm Paleocene–Eocene Thermal Event (PETM) allows the presence of photo-T-factory carbonates even in unusual latitudes (35° South). In addition to the climate-driven response of carbonate factory and resulting carbonate accumulation geometries, the presence of carbonates is also favored by the structural context. Interpreted carbonate systems are localized on the topmost of the MCC, favoring: (1) a protection against clastic influx, and (2) a favorable topography dynamic evolution, where carbonate production seems compensated by a specific thermal support. In this context, two main marine carbonate sequences have been described from the bottom to the top: sequence 1 is an isolated platform, with very sharp shelf break, potentially associated to lithothamnium builders (red algae), and sequence 2 is a prograding ramp, dominated by large benthic foraminifera. The switch of carbonate factories during this climatic optimum, well described in literature, have been poorly documented from seismic data. Thus, the Coral Sea area provide a unique opportunity to demonstrate the impact of the PETM on the evolution of carbonate factories and resulting architectures.

Theme 2. Shallow-marine carbonate depositional systems and carbonate platforms

General Session

Oral presentation

Coral reef development and sea level changes over the past 50,000 years: new evidence from the northwest shelf of Australia

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Our understanding of global sea-level changes and coral reef development are poorly constrained during Marine Isotope Stage 3 (MIS3) (60–30 ka). Australia's North West Shelf (NWS), at depths ~50–120 m, represents an ideal natural laboratory to address these knowledge gaps. In this study we investigate a unique suite of cores recovered as part of a geotechnical survey using a sea-bed rock drill from the top of a drowned platform on the NWS. Twenty cores penetrating 28 m were collected from the platform in water depths (74.8–81.6 m) forming two transects 17 km apart. High-resolution bathymetry from 3D seismic data reveals numerous distinct fossil reef and shoreline features on these platforms. We have completed detailed logging, petrologic analysis, hyperspectral scanning, sedimentary facies analysis of these cores, including a precise paleoenvironmental reconstruction based on reef assemblages, and extensive radiometric dating. We observed a complex suite of lithologies including in situ coraglal reef frameworks, well lithified to friable grainstones, packstones, and coralline algal floatstone facies separated by at least two major palaeo-soil horizons. Together with thirty C^{14}-AMS and closed-system U/Th ages spanning 10.7 to >50 ka, we define a complex but consistent record of at least four distinct chrono-stratigraphic units representing a succession of shallow-deep reef and platform settings. We can now place firm chronological constraints on a significant phase of shallow water reef development (and the position of relative sea level) towards the end of MIS3 before exposure led to reef demise as sea level fell to LGM. Deeper reef slope facies define the tops of the cores dated at ~13.2–10.7 ka, representing a major hiatus in reef growth, as deglacial sea-level rise was either too fast and/or other environmental conditions were inadequate (i.e. high terrigenous sediment flux) to allow re-establishment of active shallow water coral reef development at these locations and likely across the entire region. This study is part of a wider program to understand Quaternary carbonate platform development, sea level and environmental changes across the entire NWS in comparison with ongoing work on the north-eastern Australian margin associated with IODP Expedition 325 (Great Barrier Reef Environmental Changes).

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General Session

Oral presentation

Carbonate sediment dynamics in the Abu Dhabi lagoon

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Carbonate ramps are prominent features of continental margins and intrashelf basins throughout much of Earth's history. Among the limited number of recent analogues of the coastal portions of ancient carbonate ramps, the Abu Dhabi area of the (Persian/Arabian) Gulf stands out due to its morphologically complex array of open marine to sabkha environments. This study presents the outcome of detailed field and laboratory analyses, with the aim to provide a facies distribution model of the shallow coastal portions of the Abu Dhabi coastline and shed light on the complex interplay between coastal morphology, hydrodynamic controls and sediment biostabilisation. Unconsolidated sediment samples (n=105) were collected and analysed to quantitatively characterise grain composition (bioclasts, lithic clasts, ooids, peloids, micritic, and non-carbonate particles), grain size and sorting. The studied area is subdivided into four first-order sedimentary domains characterised by nine second-order facies types. These facies types are characterised by variable compositions of sediment grains with different size and sorting. Prevailing hydrodynamic regimes, controlled by waves and tidal current energy, are the dominant factor controlling facies distribution. Coarse-grained and well-sorted sediments accumulate under high hydrodynamic levels, while significant volumes of fine-grained and poorly sorted sediments are observed in low-energy, more restricted environments. Winnowing by waves is a key control with regard to sediment sorting while tidal currents are more important in controlling spatial size distribution. Punctuated hydrodynamic events (storms) and seafloor biostabilisation (seagrass and biofilms) superimpose first and second-order facies distribution patterns. This is relevant, as in the absence of preserved evidence for seafloor biostabilisation, misinterpretations of the palaeo-hydrodynamic level seem likely.

Theme 2. Shallow-marine carbonate depositional systems and carbonate platforms

General Session

Poster presentation

Updated facies models for the Middle Jurassic Bathonian–Callovian Upper Dhruma, and Tuwaiq Mountain Formations of Central Arabian Plate

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The Middle Jurassic, Bathonian–Callovian succession is exposed in Central Saudi Arabia along a 1000 km long escarpment, which offers the unique opportunity to study lateral facies change, key stratigraphic surfaces, and depositional patterns in laterally continuous outcrops. The focus of this study is the upper part of the Dhruma Formation (Atash and Hisyan members) and the Tuwaiq Mountain Formation, which have been reported to form one large-scale transgressive–regressive sequence. Our findings show that there is a large variety of sedimentary facies, including shallow water carbonates and marls, fluvial and marine sandstones, and iron-ooliths, which are organized in two medium-scale depositional sequences. This study presents preliminary results obtained along a 600 km segment of the escarpment. Based on five outcrop sections, each about 170 m thick and measured between Riyadh and Wadi Ad Dawasir, a sedimentary facies interpretation has been made, illustrated with microfacies. Four main classes are described: (a) carbonate facies consisting of cross-bedded oolitic intertidal limestone, bioclastic bioturbated wacke-packstone, argillaceous marls, biostromal stromatoporoid floatstone, and oncoidal packstone; (b) iron-oolitic facies consisting of iron-coated superficial ooids and spherical quartz grains in a matrix of very fine to medium grained sandstone, bioclastic sandstone or mudstone; (c) siliciclastic facies consisting of fine to coarse-grained deltaic to fluvial sandstones, with ripple cross-lamination, dm-scale bidirectional crossbedding, multi-m-scale crossbedding, and locally abundant tree trunks and plant roots and leaves. The correlations between the sections are constrained by new nannofossil age dating and marker beds that can be physically followed in the outcrops. These allow for documenting the significant lateral facies changes in this depositional system and form the basis for an interpretation in terms of depositional sequences. These preliminary results provide new insights into the facies associations of this mixed carbonate–iron oolitic–siliciclastic system, with consequences for the interpretation of the depositional environments and the evolution of the controlling factors such as climate and relative sea level.

Theme 2. Shallow-marine carbonate depositional systems and carbonate platforms

General Session

Poster presentation

"Temperate-like" seagrass development in a (sub) tropical terrigenous-influenced inner ramp setting (Middle Eocene, Urbasa–Andia Plateau, Western Pyrenees)

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Since their occurrence in the late Cretaceous, seagrasses played a major role in carbonate deposition in shallow-water settings, sustaining a prolific carbonate factory and contributing to accumulation through baffling–trapping effects. Most Paleogene occurrences developed in oligo–mesotrophic, warm-water habitats dominated by small and larger benthic foraminifera (i.e. soritids, alveolinids, miliolids). Here we describe the characteristics of several seagrass episodes in Bartonian (middle Eocene) deposits from the western Pyrenees (Navarra, North Spain), within a nearshore to inner ramp mixed carbonate–siliciclastic succession deposited under moderate–high terrigenous supply. Seagrass beds occur interbedded with high-energy nearshore siliciclastics (gravel bars, rippled and cross bedded sandstones) and inner-ramp bioclastic carbonates with mesophotic–oligophotic foraminifera (nummulitids, orthophragminids) and associated heterozoan biota (red algae, echinoderms, bryozoans). The seagrass deposits exhibit typical unsorted textures, abundant bioturbation and moderate–high terrigenous content. They comprise a skeletal association composed of epiphytic foraminifers (Peneroplis, Lobatula, Planorbulina), red algae and, distinctly, high amounts of encrusting acervulinids, most with hooked and tubular growths. The abundance of suspension-feeders relative to autotrophs and mixotrophs points to temperate waters, although the foraminiferal assemblage supports shallow and warm water conditions. Our results reveal that high siliciclastic supply and elevated nutrients levels may determine the occurrence of "temperate-like" seagrass deposits in warm water settings, similarly to enhanced heterozoan carbonate production in modern shallow tropical environments. The studied examples show a patchy distribution and comprise skeletal assemblages dominated by heterotrophs such as acervulinids, regardless the water temperature. The case study documents how the identification and correct interpretation of seagrass deposits are crucial for reconstructing palaeoecological conditions and sea level trends in ancient shallow marine environments.

This is a contribution to the Consolidated Research Group IT-1602-22 of the Basque University System.

Theme 2. Shallow-marine carbonate depositional systems and carbonate platforms

General Session

Poster presentation

Cretaceous to Middle Miocene carbonate platforms of SE Romania

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In the SE part of Romania, within the Southern Dobrogea region, the sedimentation spans the Cretaceous to Tertiary interval. Tectonically, the Southern Dobrogea belongs to the eastern part of the Moesian Platform and lies towards south the Capidava–Ovidiu Fault that separates it from the central Dobrogea. In the Southern Dobrogea, mainly a shallow to brackish sedimentation was identified with repeated transgressive and regressive events. The exposed Cretaceous deposits unveil a complete development for all the stages. Within the Lower Cretaceous, the Berriasian to lower Aptian interval is represented by marine shallow water carbonates. A depositional change is marked by a transgressive late Valanginian event, expressed by the occurrence of marls, clays and limestones, containing calcareous nannofossils of Tethyan and Boreal origin and planktonic foraminifers. In the Hauterivian–early Aptian interval, the deposition is again that of a carbonate platform. Upwards, in the middle–late Aptian interval, a fluvial–lacustrine sedimentation took place followed by Upper Cretaceous marine glauconitic sandstones and chalk. The Eocene sediments show also a shallow marine deposition, i.e., limestones with nummulites. The Miocene deposits consist of oolitic limestones, clays, sands, marls, and diatomites, sedimented mainly in the Sarmatian, an Eastern Paratethyan stage. The Sarmatian shallow carbonate platform transgressively overlies the Lower Cretaceous (Barremian to Albian), Upper Cretaceous and Paleogene (Eocene) sediments. Lithologically, the Sarmatian of the South Dobrogea is mainly characterized by sands, rudites, organogenic limestones, oolitic limestones, clays and marls. Within the lower–middle Sarmatian boundary interval, i.e., between the Volhynian and Bessarabian substages, the paleoenvironment has changed; a semi-enclosed sea with brackish faunas covered the area of Dobrogea. Based on the faunas, temporarily connections with open marine basins were pointed out. Upwards the Upper Miocene there is a shift from a shallow marine setting environment to brackish and fresh water ones.

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General Session

Poster presentation

Diagenetic evolution of platform carbonates flanking diapiric structures: example from Tazoult salt wall (High Atlas, Morocco)

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The Central High Atlas of Morocco is a double-verging major diapiric province encompassing SW–NE trending salt-related ridges and Lower to Middle Jurassic sediments over wide synclines (minibasins) in between them. Typically, the Pliensbachian and Bajocian carbonate platforms flanking diapirs appear partially dolomitized next to the diapir wall. The interpretation of the diagenetic evolution of these dolomitized carbonates may be complex due to different fracturing patterns/brecciation, fluid pathways, localised uplift related with salt tectonics, among others. The present work aims to study the dolomitization affecting the platform carbonates in the vicinity of the Tazoult salt wall. Specifically, the objectives are: (i) to estimate the distribution and extension of the dolomitization (ii) to ascertain the diagenetic source, type and pathway of the fluids that induced such diagenetic alteration, and (iii) to assess the role of salt diapirs on fluid circulation. Remote sensing mapping using high-resolution orthorectified satellite images is used to delimit the extension and geometry of the dolomitized area. Petrological work includes standard microscopy and cathodoluminescence petrography to distinguish diagenetic dolomite and carbonate phases. C and O stable isotope analyses are conducted to interpret the origin of the diagenetic fluids. The results highlight the major influence of diapirism on fluid circulation, and thus in the diagenetic alterations, in salt-related basins.

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General Session

Poster presentation

Carbonate depositional models based on well-logging data statistics analysis: a case study of the Callovian–Oxfordian stage in The Amu Darya Basin, Abu Dhabi

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With the development of well-logging technology, more and more special well-logging methods were used in formation detection. However, a large number of well-logging data increases the difficulty of data screening and utilization, and it is hard to guarantee the characterization of formation characteristics of the well-logging parameters adopted. Therefore, the lithology and sedimentary facies identified are not accurate, which is easy to misjudge the depositional model. To solve this problem, this paper takes the strata of the Callovian–Oxfordian stage in the Amu Darya Basin in Abu Dhabi as an example. Based on the core description, thin section, and paleontological identification, we use statistical multiple regression analysis and cluster analysis to process the well-logging data, calculate the influence factors of various well-logging curves on the results, construct Euclidean space to judge their correlation, and conduct screening. It is preferred to analyze data with the high characterization of stratigraphic characteristics. The lithology was identified, the sedimentary facies and sequence were divided by the high characteristic factors, and a reliable depositional model was established. Finally, it was determined that the strata belonged to the sedimentary system of the carbonate platform. Six sedimentary facies types were identified and SQ1, SQ2, and SQ3 third-order sequences could be divided. It is revealed that the Callovian–Oxfordian stage in this area has experienced the platform edge ramp, platform-edge reef-shoal, open platform, and restricted platform into the evaporative platform in turn, which constituted the multi-phase transgressive–regressive cycles. Finally, the depositional model of the “marginal gentle slope platform” has been established. This paper provides a new method for well-logging data processing and carbonate reservoir research and has a certain reference value for carbonate reservoir exploration.

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General Session

Poster presentation

Facies, depositional setting and sequence stratigraphic evolution of Cenomanian to Turonian shallow water platform carbonates from southern and central Jordan

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The Upper Cretaceous (uppermost Albian–Turonian) Ajlun Group in Jordan consists of shallow-water carbonates, marls and sandstones deposited along a passive continental margin of the Neo-Tethys Ocean. Excellent outcrops along the Dead Sea Transform in Jordan allow for thorough sedimentological analysis and sequence stratigraphic correlations from microfacies- to basin-scale. The objective of this study is to establish a significantly improved regional-scale high-resolution sequence stratigraphic framework, utilizing outcrop and subsurface data, which forms the basis for further detailed paleontological and geochemical studies. Here we present preliminary results of the initial field study, covering a 150 km transect with five sections with a N–S orientation and thickness variations from 200 to 400 m, comprising the Naur, Fuheis, Hummar, Shueib, Wadi As Sir and Khureij formations (Ajlun Group). Lateral correlations, constrained by new nannofossil biostratigraphy, confirm previous lithostratigraphic frameworks and highlight the regional-scale architecture with a distinct proximal (S) to distal (N) trend, with increased carbonate accumulation towards the north and increased terrestrial input from the south. In addition, the results of a detailed >350 m outcrop section complemented by microfacies analysis of 152 thin sections are presented, spanning the entire Ajlun succession. The section records the initial transgression of the Naur deposits and the subsequent deposition of mostly sub- & supratidal carbonates. The overlying Fuheis, Hummar and Shueib formations are characterized by thick marl deposits with subordinate carbonate units, reflecting a significant reduction in shallow water carbonate production. A marked relative sea level drop exposing the platform at the top of the Shueib formation (Middle Turonian) is evident from sabkha/salina and fluvial deposits. At the top of the section, the overlying Upper Turonian Wadi As Sir/Khureij carbonates are composed of sub- to supratidal carbonates, likely deposited on a ramp setting. These initial results highlight the pronounced environmental changes which occurred during the evolution of the depositional systems of the Ajlun Group and provide the basis for future high-resolution sequence stratigraphy on a regional scale.

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General Session

Poster presentation

Environmental changes during the late Holocene in the lagoon of Rasdhoo atoll (Maldives)

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Coral reef habitats are changing due to anthropogenic influences. To better understand this process, it is important to reconstruct the natural variability in reef communities from geological archives. In this study, Holocene sediments of three drill cores from the lagoon of Rasdhoo Atoll, Maldives, were examined. Sediment analysis included quantification of different groups of organismal residues (e.g., corals, echinoids, ichthyoliths). In addition, growth forms and the degree of encrustation of coral fragments, as well as changes in grain size distributions were detailed. The aim was to identify fluctuations of these parameters over time in response to changes in the environment. The sediment composition in the three cores was substantially different. Fragments of reef corals (e.g., *Acropora* sp., *Seriatopora hystrix*) were found preferentially in two cores. They were likely transported into the lagoon from a nearby large patch reef and the outer reef by enhanced water circulation due to channels in the reef margin. Corals show a diverse faunal community over the entire period studied back to ca. 4000 years BP. Fragments of echinoids were identified as *Echinometra* sp., *Diadema* sp. and Cidaridae. The proportion of all organismal remains exhibit different trends in the three cores. Reasons for this include independent site-specific ecological changes, the ongoing growth of the patch reef in the central lagoon, as well as the formation of a sand spit in the northwestern lagoon and resultant changes in the hydrodynamic conditions. The latter is evident from fluctuations in grain size distribution. There is also evidence in the sediment composition for two tsunami events, e.g., distinctive, short-term increases in reef coral and mollusc fragments. This study highlights that atoll lagoons have great potential as archives of ecological and environmental change, as they store information on faunal composition, geomorphological changes, and short-term events.

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General Session

Poster presentation

Development of reef microbialites from Eemian portions of the Grotto Beach Formation, San Salvador Island, Bahamas

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Microbialites from the Eemian/MIS 5e fossil reef exposed at Cockburn Town quarry (western San Salvador Island) are a key feature distinguishing two stages of reef development within the uppermost reef interval of the Cockburn Town Member (Grotto Beach Fm). Detailed examination of a 34 m core drilled through the fossil reefs near the southern island/platform margin in 2019, as well as recent re-examination of a 15 m core collected in 1997 a few meters landward of the quarry exposures, provide additional insights into the areal extent and distribution of microbialites, the nature of the Devil's Point Discontinuity (DPD) separating reef Stages I (lower) and II (upper), and the response of nearshore shallow subtidal carbonate platform settings to climate-driven sea-level change.

Microbialites are only recognized within Stage I boundstones. Stage I deposits also reveal that: 1) reef boundstones formed primarily around branches of *Acropora cervicornis*; 2) corals were directly coated with a diverse array of skeletal encrusters (coralline red algae, serpulids, and 3+ genera of foraminifera – including *Homotrema*), and then overlapped by micritic microbialite coatings with some foraminifera (notably *Carpenteria*); 3) microbialite coatings within reef boundstones become progressively thicker and more extensive upward toward the DPD; 4) both outcrop and cores largely comprise crudely stratified boundstone layers separated by thin carbonate sand (grainstone) drapes; 5) these couplets laterally flank rare unstratified boundstone masses but display limited vertical aggradation; 6) grainstone drapes thicken toward the lower flanks of each couplet in outcrop; and 7) grainstone drapes are generally thicker in the core sections, likely reflecting more landward proximity to shoreface sands.

Presence of identical boundstone–grainstone couplets in both western and southern platform cores suggest that these facies are not just a local response to environmental change. Patterns of boundstone development favor a short-term sea-level drop for the origin of Stage I microbialites and the DPD. Under such conditions, reef boundstone development was likely facilitated by episodic storm coral fragmentation and transport, nearshore nutrification during post-storm run-off, and subsequent beach shoreface progradation.

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General Session

Poster presentation

Tortonian–Early Messinian carbonate ramp development in the Paleoadriatic domain, the role of Mediterranean evolution on carbonate factory and facies belt: insight from the Lithothamnion Limestone (Majella, Central Apennines, Italy)

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The Lithothamnion Limestone constitutes the uppermost, shallow-water unit of the Bolognano Fm. The latter represents the northern sector of Apulian Carbonate Platform developing in the central Mediterranean domain (Paleoadriatic domain), cropping out in the Majella Mountain (Palena, Central Italy). The profile is consistent with a homoclinal carbonate ramp, with a wide middle ramp in which coralline algae, mainly forming the marl facies, dominated the carbonate production. The outer ramp, in the aphotic zone, was characterized by bioturbated hemipelagic marls with planktonic foraminifera and pectinids. The inner ramp was widely colonized by seagrass meadows interfingering with the marl facies of the middle ramp. The main biota producing carbonate sediments of this vegetated area were benthic foraminifers (mainly porcelaneous foraminifers) and red algae, together with abundant serpulids. The shallowest facies of the inner ramp are represented by oolitic shoals and coral buildups generally encrusted by serpulids and red algae. This ramp developed during the late Tortonian to early Messinian interval, when coral reef complexes abundantly developed in Mediterranean. In this work, we analyse and evaluate the environmental conditions that prevented the development of coral reefs in the Paleoadriatic domain. Geochemical and compositional analyses point towards the deterioration of trophic and, more in general, environmental conditions, coinciding with a strong increase of terrigenous input, organic matter and reducing trace elements. This change coincides with climatic changes induced by precessional forcing starting at 7.1 Ma due to the progressive closure of the connection with the Atlantic Ocean in the Rifian corridors. In this context, the terrigenous sedimentation in the Adriatic foredeeps, related to the Apennine evolution during the early Messinian, could have contributed to amplify the progressive deterioration of environmental conditions in the basin.

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General Session

Poster presentation

Characteristics of subaerial exposure surfaces marking terrestrial periods during Late Cretaceous to Early Palaeogene carbonate platform evolution, the island of Brač (Croatia)

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Upper Cretaceous to Lower Palaeogene shallow marine carbonates are the youngest deposits on the Brač Island and contain numerous subaerial exposure surfaces marked by karstification and soil formation. The most prominent emersion surface marks regional unconformity and occurs at the top of the shallow marine Sumartin fm.

Four correlative sections on different parts of the island reveal temporally and spatially differential exhumation of parts of the former shallow Adriatic Carbonate Platform (AdCP). From west to east the locations are: Cape Gomilica, Likva Cove, Babin Loz Cove and Cape Debelo Čelo. Irregular unconformity in the Cape Gomilica section cuts the upper Maastrichtian part of the Sumartin fm. and is marked with up to 1 m thick transgressive breccia. Overlaying palustrine carbonates (micrites with gastropods including *Stomatopsis* sp., charophyta remains and dasyclad algae) are followed by upper Palaeocene limestones rich in miliolid foraminifera (including *Haymanella* sp.). At Likva Cove unconformity truncates lower Danian part of the Sumartin fm., shows irregular relief and up to 2.5 m thick breccia bed composed of terrestrial carbonate clasts (black pebbles, calcretes, clasts with rhizoliths, *Microcodium* aggregates, alveolar septal fabric) imbedded in clayey calcareous and reddish matrix. The overlaying palustrine carbonates with rare *Kayseriella decastroi* are of late Danian age. At Babin Loz Cove palaeokarst surface is developed in mid–upper Maastrichtian Sumartin fm. and characterized by circular dissolution potholes several metres deep filled with reddish bauxitic material and lithoclasts of terrestrial carbonates. The overlying foraminiferal limestones are of Eocene age. At Cape Debelo Čelo unconformity truncates the Maastrichtian part of the Sumartin fm. and is overlain with 10 m thick carbonate breccia (reworked terrestrial carbonates) followed by palustrine limestones, and finally by shallow marine carbonates.

Terrestrial periods recorded in the Upper Cretaceous to Lower Palaeogene Brač carbonates are the result of a gradual development of a forebulge in front of the emerging Dinaridic orogen. They record a regional change from the Mesozoic semi-isolated AdCP to complex Palaeogene carbonate ramp system as well as change from the warm humid climate to semi-arid conditions.

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Poster presentation

Facies analysis, biostratigraphy and isotope chemostratigraphy of the Upper Jurassic–lowermost Cretaceous transition in the eastern Getic Carbonate Platform

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The studied deposits are located in the eastern part of the Getic Carbonate Platform. Approximately 3000 carbonate samples were collected from 44 sections located in the Piatra Craiului Massif and the surroundings of Brașov city (Postăvaru and Piatra Mare Massifs). Facies analysis indicates the presence of slope, platform margin and inner platform deposits. The isotope chemostratigraphic analysis was performed on samples extracted from black pebble bearing horizons and layers pigmented with iron oxides. The micropaleontological assemblage consists of dasycladalean algae [*Aloisalthella sulcata* (Alth), *Clypeina parasolkani* Farinacci and Radoičić, *Salpingoporella pygmaea* (Gümbel), *Seliporella neocomiensis* Radoičić, *Steinmanniporella kapelensis* (Sokač & Nikler), *Petrascula bursiformis* Etallon, *Neoteutloporella socialis* (Praturlon)], foraminifera [*Anchispirocyclina lusitanica* Egger, *Coscinoconus alpinus* (Leupold), *Coscinoconus cherchiae* (Arnaud-Vanneau et al.), *Coscinoconus delphinensis* (Arnaud-Vanneau et al.), *Coscinoconus sagittarius* (Arnaud-Vanneau et al.), *Coscinoconus campanellus* (Arnaud-Vanneau et al.), *Haplophragmoides joukowskyi* Charollais et al., *Labyrinthina mirabilis* Weynschenk, *Meandrospira favrei* (Charollais et al.), *Montsalevia salevensis* (Charollais et al.), *Mouladella jourdanensis* (Foury and Moullade), *Neokilianina rahonensis* Foury & Vincent, *Nautiloculina brönimanni* Arnaud-Vanneau & Peybernès, *Parurgonina caelinensis* Cuvillier et al., *Protopeneroplis ultragranulata* Gorbatchik, *Pseudotextulariella courtionensis* Brönnimann] and pelagic microorganisms [*Calpionella alpina* Lorenz, *Calpionella eliptica* Cadish, *Crassicollaria brevis* Remane, *Crassicollaria intermedia* Durand-Delga, *Crassicollaria massutiniana* Colom, *Crassicollaria parvula* Remane, *Saccoccoma* sp.]. This microfossil assemblage documents the Upper Jurassic–lowermost Cretaceous transition in the studied areas, indicating that carbonate deposition was continuous accross the Kimmeridgian–lower Valanginian or Kimmeridgian–Berriasian intervals. The isotope chemostratigraphic analysis indicates that subaerial exposure occured at certain intervals within the studied sections.

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General Session

Poster presentation

Brecciated carbonate rocks within Late Cretaceous Bagh Group, Central India: Implications on genesis and paleoenvironment

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Two types of carbonate breccias are recorded from the uppermost part of the Late Cretaceous Bryozoan Limestone Formation, exposed within the Narmada Rift Basin, Central India. The origin and genesis of the breccias are established from stratigraphic and field relationships, petrographic studies, and geochemical analysis. Based on their environmental origin, breccias are classified into depositional (lithoclastic) and non-depositional (solution collapse) breccias. The lithoclastic breccias are characterized by i) sub-angular to sub-rounded, gravel-sized clasts of lime-grainstone (Bryozoan grainstone), ii) a lower proportion of both marly calcitic matrix and sparry calcitic cement, and iii) truncations of fossil fragments and other allochemical grains along the clast margins. Moreover, the solution collapse breccias are characterized by i) angular to subangular clasts of dark grey, fine to medium-grained microcrystalline dolomites floating within a calcitic matrix, ii) dissection of clasts by veins of clear coarse crystalline dolomites, and iii) evident stages of dedolomitization textures. Based on matrix, framework components, clast size and composition, four types of materials are identified within the solution breccias, namely, bioclasts with calcitic micrite, dolomitic clasts (600–50 μm) floating in calcitic micrite, dolomitic clasts (300–10 μm) floating in calcitic micrite, and calcitic mud (with no clasts), that periodically infilled the brecciated units during different stages of genesis. The lithoclastic limestone resembles an intraformational breccia, probably formed under periodic sea-level changes and small-scale upliftments caused by faulting, resulting in subsequent erosion and redeposition of the previously lithified hardgrounds found beneath the brecciated units. The overlying solution collapse breccias were deposited under shallow, restricted, hypersaline, lagoonal environments or along supratidal mudflats, which later evolved into a sabkha sequence under lowstand conditions. The breccias evolved as a result of the simultaneous occurrence of processes such as desiccation, collapse, gradual subsidence, evaporite flowage, and small-scale dissolution and precipitation, active through the initial and final stages of brecciation.

Theme 2. Shallow-marine carbonate depositional systems and carbonate platforms

General Session

Poster presentation

Carbonate factory response through the MECO event: insight from the Middle Eocene of the Apulia Carbonate Platform

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During the Eocene period, shallow-water carbonate systems were significantly influenced by climate fluctuations. Following the peak temperatures of the Early Eocene Climatic Optimum (EECO), a general cooling trend began, with short-lived (< 200 Kyr) warming events occurring alongside it. During the early Bartonian (around 40.1 Ma), a warming event known as the Middle Eocene Climatic Optimum (MECO) occurred, lasting approximately 500,000 years. In this scenario the types and calcification rates of marine organisms such as corals and larger benthic foraminifera (LBZ) were significantly impacted by the influence of global CO_2 and oceanographic changes, which had a major effect on photic carbonate factories. To better understand the effects of these factors on carbonate factories, a detailed study of shallow-water facies types, distributions, and evolution was conducted. The Middle Eocene Monte Saraceno sequence, located on the eastern margin of the Apulia Carbonate Platform (Gargano Promontory, southern Italy), was selected as an ideal case study to investigate the relationships between carbonate factory types and climatic changes. This study identified two distinct intervals with different carbonate production, separated by a clear, sharp boundary. The lower interval consists of clinostratified thick beds of rudstone to floatstone, mostly made up of various large *Nummulites* tests, indicating an uppermost Lutetian to early Bartonian age (Shallow Benthic Zone 16–17). In contrast, the upper interval consists of coral floatstone to rudstone with a packstone matrix, rich in branching corals in association with gastropods, bivalves, and rare small LBF. The appearance of *Heterostegina* in this interval indicates a late Bartonian age (Shallow Benthic Zone 18). By integrating biostratigraphic and stable isotope data, the lower interval, mostly composed of *Nummulites*, was linked to the MECO and post-MECO intervals, during which higher global temperatures seemed to be tolerated by LBF, as occurred in the Early Eocene. However, the sharp transition to a coral-dominated carbonate factory during the late Bartonian could be attributed to a drop in temperature below the threshold for coral flourishment, rather than a simple facies shift caused by a relative sea-level drop.

Theme 2. Shallow-marine carbonate depositional systems and carbonate platforms

General Session

Poster presentation

Contrasting shorelines of an Albian carbonate platform (Cantabria, Spain): tidal flats versus eroded–bioturbated emergent surfaces

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The peritidal facies of Middle Cretaceous carbonate platforms of north Spain usually lack the typical cap of tidal flat laminites. Instead, they are formed by shallow subtidal facies capped directly by brecciated, bioturbated or rooted emergent surfaces. Here, we show these two types of peritidal cap facies developing contemporaneously in two opposite shorelines of a Middle–Upper Albian carbonate platform of north Spain developed in two tectono-sedimentary domains with different structural and stratigraphic styles. This platform (Barcenaciones Fm) deposited adjacent to the northern margin of the Iberian Plate, in a tidally-influenced sub-basin formed by rift tectonics (North-Cantabrian subbasin, NW margin of the Basque–Cantabrian basin). In the western shoreline (Nansa block), the Cretaceous succession rest unconformably on Paleozoic or Triassic basement and the Middle–Upper Albian carbonate platform is directly connected to the peneplained emergent margin of the Iberian plate. Here, the peritidal facies are made of 1–4 m thick packages of intertidal, sub-parallel planar to low-amplitude hemispheroidal microbial laminites formed in a tidal flat and capped by supratidal brecciation with flat pebbles and dislocated lamination (semiarid periods). These limestone laminite beds alternate with centimetric layers of quartz siltstones and silty marls with abundant plant leaves and lignite (humid periods). These facies intercalate transgressive subtidal cross-bedded bioclastic-oolitic tidal bars and erosive tidal channels up to 2 m thick. In the opposite platform shoreline located in the Cuchía–Suances block, the succession deposited on a E–W narrow structural high that limited the subbasin to the north. Here, the peritidal facies of the Barcenaciones Fm, which shows a very reduced thickness, consists of the stacking of up to 1.5 m thick beds of subtidal coral-rudist wackestone and bioturbated grainstones capped directly by very irregular emergent surfaces with associated erosion, bioturbation and draped by intraclastic lags and centimetric sandstones layers with bioclastic lags and quartzite pebbles. We propose that a combination of inherited topography, tectonic accommodation, isolation, water energy and high-frequency climate changes could cause the different types of peritidal caps.

Theme 2. Shallow-marine carbonate depositional systems and carbonate platforms

General Session

Poster presentation

Paleogeographic evolution of the Early–Middle Jurassic carbonate succession of the Sciacca area (southwestern Sicily)

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The sedimentological–stratigraphic study of the Mesozoic carbonates outcropping in the Sciacca area (southwestern Sicily) provided new data on the paleogeographic evolution of the southern sector of the western Tethys margin during the Early–Middle Jurassic. The study area is the sector of the Sicilian–Maghrebian Chain that was affected during the Jurassic by a transtensional tectonics related to the opening of Alpine Tethys.

We analysed three sections at Mt San Calogero (A and B) and Rocca Porcaria (C), each 6 km far from the others. The microfacies analysis allowed to distinguish two units separated by an unconformity: i) a shallow water limestone unit and ii) a condensed pelagic unit.

The shallow water unit consists of parallel-bedded peritidal limestone organized in shallowing upward cycles. The latter are characterized by wackestone/packstone with abundant benthic foraminifera (*Siphovalvulina* sp. and *Lituosepta* sp.), calcareous algae (*Paleodasycladus mediterraneus*, *Thaumatoporella parvovesiculifera* and *Cayeuxia* sp.) and small bivalves. This microfacies association allowed to date them to Sinemurian–Pliensbachian differently from Ruggieri (1959), who indicated Upper Triassic.

An interval of non-deposition, represented by Fe–Mn oxide crust, occurs between the two units only along the section B.

The condensed pelagic unit consists of a level of packstone with thin-shelled bivalves (*Bositra* sp.) and planktonic foraminifera passing upward to ammonites-rich nodular limestone. The Bositra packstone was attributed to late Bajocian–early Oxfordian p.p. thanks to a correlation with neighbouring sections (Contrada Monzealese and Contrada Diesi). The nodular limestone of section A was ascribed to the middle Oxfordian by the association of *Gregoriceras riazi* and *Gregoriceras fouquei*.

A level of wackestone/packstone with tangential micritic ooids and planktonic foraminifera occurs only at section A between the Bositra packstone and the nodular ammonitic limestone. The abrupt transition from the shallow water and the condensed pelagic unit testifies the drowning of this sector of the western Tethys margin. Moreover, the microfacies analyses along the three sections reflects differences in the sedimentation processes tectonically influenced by the rifting of the Alpine Tethys.

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General Session

Poster presentation

Mixed carbonate–siliciclastic tidal sedimentation in the Río Alías Strait, Early Pliocene, SE Spain

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The Río Alías Strait developed in the Early Pliocene as a narrow marine corridor at the connection of the open Mediterranean Sea and the northeastern margin of the Almería–Níjar Basin in the eastern Betic Cordillera (SE Spain). This strait was structurally controlled by the Carboneras fault, a sinistral strike-slip fault system that evolved under a transpressive regime since the Late Miocene. The mixed carbonate–siliciclastic deposits in the strait record the effect of tidal current amplification in sediment distribution. We document the sedimentological features of the Río Alías Strait deposits and their spatial and temporal distribution in seven sections at well-exposed outcrops, interpreting its sedimentary dynamics within the context of existing strait facies models. Large-scale (>10 m high) submarine dunes formed by superimposed, mostly 3D bedforms moved parallel to the strait margins under the influence of strong tidal currents amplified at the strait entrance and exit. Dunes were distributed along cross-bedded zones located at the eastern and western sectors with a dominant migration towards the west and east, respectively. At the western sector, the initial deposits were cross-bedded barnacle rudstones, probably fed from barnacles that lived attached to the basement walls. Dunes from both zones passed into burrowed sandy silts and sandsheets in the central sector. Sandsheets with small-scale bedforms also accumulated at the strait exits. Sediments are mixed carbonates and siliciclastics, medium to granule in grain size, at all sections along the strait, although the relative proportion of bioclasts is generally higher in the western sector and up section. Tectonic uplift of the Sierra Cabrera at the northern strait margin drove the progradation of fan delta deposits and progressive infilling led to the closure of the Río Alías Strait at the end of the Early Pliocene.

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General Session

Poster presentation

Sedimentology and palaeontology of tidal carbonates from the Upper Triassic of the Internal Zones of the Betic Cordillera (SE Spain)

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This work analyses a well-preserved sequence from the dolomitic Trevenque Unit of the Alpujarride Complex (Internal Zones of the Betic Cordillera, SE Spain) focused in the taphonomy of bivalve shell beds and the paleoenvironmental interpretation. The results are based on field mapping, facies and taphonomic analysis including point-counts with 1 cm-mesh-light two-dimensional grids for grain/matrix abundance and shell mean size, position within the bed, disarticulation and breakage, estimated by counting on bedding surfaces of 50 x 50 cm squares. Carbonate fabrics and structures were observed in thin sections and polished slabs. A detailed stratigraphic column is 13.1 m thick distributed in seven beds. The succession is massive dolostone at the base and gradually change upward into a well-laminated dolostone with bird's-eye structures intercalated with massive dolostone with thin lamination sets separated by massive thick intervals with megalodontid bivalves. These bivalves are up to 5 cm in size and occur in patches (10 cm thick x 50 cm length). The results of point-counting analyses show that megalodontids represent an average 35.9 % of the rock. The laminated facies are interpreted as algal mats from an intertidal environment with subaerial exposure represented by bird's-eye structures. The presence of megalodontids indicates a subtidal shallow-waters environment like a lagoon. Megalodontid distribution in patches with low rates of disarticulation and fragmentation is coherent with a low energy environment such as lagoon. The vertical distribution of facies is interpreted as a deepening upwards sequence with intertidal facies represented by laminites followed by the lagoonal megalodontid-bearing dolostones. Accordingly, the sequence here described is proposed as a lofer cycle exclusively recording the members B (intertidal laminites) and C (subtidal lagoon with megalodontids). This interpretation verifies and expands previous paleoenvironmental and paleogeographycal reconstructions of the facies belts of the Alpujarride Complex and improves our knowledge of the shallow-water domains of the westerm Tethys during the Upper Triassic.

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General Session

Poster presentation

Current pathways in rudist-dominated Upper Cretaceous shelves. Case studies from the Adria Promontory

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Shallow-water, late Cretaceous, rudist-rich limestones have been studied from different localities in southern Italy and Croatia in which outcrop conditions show an excellent overview of the lateral and vertical evolution of rudist bodies and allow their geometry and the dynamic aspects to be reconstructed. Rudists gave rise to wide biostromal bodies and supplied most of the skeletal debris via bioerosion and minor physical breakdown. The evolution of rudist lithosomes was controlled by the environmental hydrodynamic conditions. The stratigraphic architecture and facies characteristics suggest open depositional settings such that facies transition is very gradual and the facies belts are broad, while deposits related to distinct wave-resistant biogenic frameworks are absent. In such a depositional system the sea bottoms were presumably characterized by a low bathymetric slope on which the wave energy was dissipated along a wide shelf, resulting in a general low-energy environments. As a consequence the storms were low effective, with waves dampened for clutch on the bottom, testified from the maintenance in situ of the fine fraction, from the spread of lithosomes with rudists maintained in growth position and from the overall good preservation of the reworked bivalves, often still conjoined. The gross lenticular geometry of the shell beds could be related to the abovementioned patterns of weak, maybe channelized, currents and/or pathways. In most cases, infact, lithosomes can be considered as a multistorey growth in channel-like systems in a persistently subtidal setting. Tidal currents and/or events of greater energy resulted in currents of preferential flow that created a network of small channel-like depressions along which the vivifying effect of the flows allowed the colonization and the survival of the rudists, also along the edges of the channels. The flow zones, instead, came overwhelmed from shells only weakly displaced. In such a depositional context, rudist colonization assumes particular importance as they document their ability to exploit a wide array of environments, in part referable to that occupied by oysters in Recent seas, and reflecting the probable opportunistic nature of rudists.

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General Session

Poster presentation

A benthic community biodiversity crisis documented on a Rhaetian carbonate succession from Western Tethys (Sicily)

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A biodiversity crisis in the benthic communities was detected on Rhaetian stratigraphic horizons from a western Tethyan carbonate platform. The studied succession consists of a continuous Upper Triassic to Lower Jurassic peritidal limestone organized in shallowing upward cycles cropping out at Mt Sparagio (western Sicily). On the basis of the abundance and diversity of the benthic communities in the subtidal facies, the studied section was divided into three informal units. Starting from the base, the Unit A contains very abundant and highly diverse fossiliferous assemblages of corals, very large megalodontoids (up to 40 cm) and large *Triasina hantkeni* (up to 1 mm) among other benthic foraminifera. Upward, Unit B is characterized by a reduction of biodiversity, abundance and shell size of megalodontoids that reach a dimension up to 15 cm and *T. hantkeni* is still present. The top of Unit B is recognized by a distinctive oolitic level. Up-section, after a barren interval rich in calcispherae, the absence of the benthic community documented in Units A and B and a bloom of the problematic alga *Thaumatoporella parvovesiculifera* characterize Unit C. Upward, the occurrence of rare specimens of the benthic foraminifer *Siphovalvulina* sp. indicates the gradual recovery of the Jurassic benthic community. The stable isotope analyses (C, O and S) seem to correlate to the biodiversity crisis between Unit A and Unit B. In detail, a negative trend of $\delta^{18}O_{carb}$ values, corresponding to an increase in temperature, matches with the drastic reduction both in dimension and diversity of the megalodontoid families between Units A and B. Between Unit B and C, across the Triassic/Jurassic boundary, a strong positive peak of both $\delta^{18}O_{carb}$ and $\delta^{34}S_{CAS}$ marks the biodiversity crises observed at the End Triassic Extinction, highlighting a close relationship between climatic changes and mass extinction events.

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General Session

Oral presentation

Marion contourite depositional system: implications on sea-level studies

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The morphology of contourite drifts is strongly influenced by the interaction of the currents with the sea floor topography and obstacles. A prime example of such interaction occurs on the Marion Plateau, where the East Australian Current flows across and around several Miocene isolated platforms. The resulting Marion Contourite Depositional System (CDS) covers most of the 220-km-wide and 460-km-long Marion Plateau in northeast Australia, thus, consists of five different drift types that are sheeted, elongated–mounded, confined, periplatform, and multi-crested drifts. The erosional features within this CDS include a marginal valley, moats, and an erosional terrace. In addition, current-swept platforms with iron–manganese crusts document non-depositional hiatus. Changes in the contourite drift geometry and the migration of the paleo-moats represent archives of the onset, intensification, and lowering of bottom current strengths. A hardground at sequence boundary B6/5 marks the onset of the East Australian Current at 13.4 Ma. At the Miocene–Pliocene boundary at 5.3 Ma, the contourite drift depocenter shifts dramatically, reflecting another strengthening of the current. A down-stepped package along the Northern Marion Platform that was previously interpreted as a lowstand platform and used to calculate a late Middle Miocene sea-level fall is here interpreted as the first drift sequence of the Marion Plateau. The age of the base of this drift is 13.4 Ma, which makes the onset time equivalent to the onset of the current system in the Indian Ocean.

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General Session

Oral presentation

Restricted to open-marine Middle Triassic basins of the Dinarides and their radiolarian faunas

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Late Anisian rifting resulted in a complex horst-and-graben paleotopography of the Adriatic continental margin. The most deeply subsided basins (e.g. Budva, Bosnian and Slovenian basins) remained sites of pelagic sedimentation until the latest Cretaceous. Shallower basins formed on structural highs, which were internally differentiated into several fault blocks. These shallow basins were short lived, limited to the interval between the Late Anisian to Ladinian or earliest Carnian, when they were completely filled in so that sedimentation of platform carbonates was again established in a wider area. The High Karst Zone in the External Dinarides preserves two types of sequences from this short pelagic episode. Both are characterized by micritic limestone and chert, generally include pyroclastic rocks (Pietra Verde), and locally contain carbonate breccia and calcarenite. The most obvious difference is the color of the rocks. The successions in the center of the High Karst Zone are dark grey to black due to the presence of organic matter, which may have been related to stratified water column and/or poor open-marine connections in a restricted intra-platform basin. In contrast, the pelagic limestone and chert at the margins of the High Karst swell are light to vivid red, in places greenish or light grey to pink. This latter lithology is comparable with the Buchenstein Formation of the Southern Alps. We investigated radiolarians from several Buchenstein type sections and from one organic-matter-rich section located at Mt. Svilaja in Dalmatia. The radiolarian assemblages of the Buchenstein type sections contain up to 80 genera and include multicyrtid nassellarians that are generally regarded as deeper-dwelling morphotypes and are also common in the sedimentary cover of Triassic ophiolites. The radiolarian assemblage of Mt. Svilaja consists of only 20 genera. Spumellarians and entactinarians are abundant but nassellarians account for only 5% and are represented exclusively by monocyrtids. A similar assemblage was described from the San Giorgio Dolomite in the westernmost part of the Southern Alps. Such impoverished assemblages with high predominance of surface-dwelling taxa are apparently characteristic of restricted oxygen-deficient basins that were separated from the open ocean by topographic barriers.

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General Session

Oral presentation

Towards the concise model of the latest Jurassic–earliest Cretaceous climate and oceanographic change in the Western Tethys

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The J/K transition was characterized by several distinct paleoenvironmental processes, such as the late Tithonian–early Berriasian climate aridization and the late Berriasian tectonic uplift of the Neo-Tethyan Collision Belt. Here, geochemical and calcareous nannofossil data from the Tithonian–Berriasian of the Transdanubian Range (Hungary) are integrated and interpreted in terms of paleoenvironment and its evolution. Paleogeographic position in between the western Neo-Tethys and the Alpine Atlantic oceans, along with high resolution sampling and abundant data of various type favour this area as a reference for further supra-regional investigations. Consequently, correlation and comparison of the resultant paleoenvironmental scenario with various paleoclimate, paleoredox and paleoproductivity data coming from different sedimentary zones of the western Tethyan realm (High-Tatric and Lower Sub-Tatric zones of the Central Western Carpathians, and Pieniny Klippen Belt) allow to answer the question whether any common superior mechanism controlled their deposition.

In result, the signal of the late Tithonian–early Berriasian aridization, recorded in K-leaching proxies, was found to be typical of both the Transdanubian Range and auxiliary sections. Importantly, this phenomenon coincided with oxygen depletion at the seafloor (i.e. elevated authigenic U and Fe/Al) as well as increased burial of micronutrients (e.g. enrichment factor of P and Zn). Furthermore, nannofossil assemblages (i.e. abundance of huge *Watznaueria* and *Nannoconus*) point to oligotrophic and relatively cool surface waters during this time. These observations are interpreted as resulting from climate change affecting both atmospheric and oceanic circulations. Accordingly, the late Tithonian cooling is considered to lower the thermal gradient between landmasses and the ocean, decreasing also the intensity of atmospheric circulation. Weakened winds, especially monsoons, might not only favoured aridization, but should also restrict the efficiency of Ekman transport (so-called monsoonal up- and downwelling). In result, the large part of the ocean become stratified, what should have driven the oxygen depletion at its bottom on one hand and limit the uptake of nutrients on other.

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General Session

Oral presentation

Deep-sea brine pools deliver an exquisite record of climate and tectonic events in the Gulf of Aqaba (Red Sea)

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We present the NEOM Brine Pools, the first complex of brine pools discovered in the Gulf of Aqaba. The discovery was made at 1,770 m water depth and consists of one large pool (10,000 sq. m) flanked by three minor ones (<10 m^2). Situated immediately at the toe-of-slope, the largest of the NEOM brine pools episodically receives terrestrial outwash from the Saudi coastal plain. A transect of cores through this pool's bed reveals a stratigraphy spanning the last 1,500 yrs. Major terrestrial inputs to the basin are recorded once per century, which we attribute to tsunami. Turbidite beds, meanwhile, deposit every 25 yrs. and likely record both flashfloods and the pervasive seismicity of the Aragonese Deep, the pull-apart basin in which the pools situate. Such signals are exquisitely preserved beneath the pools as bioturbating organisms cannot occupy the harsh hypersaline, anoxic brine. These observations extend the known geographical range of Red Sea brine pools, introduce a new sediment archive of event horizons, and document a new bathyal ecosystem in the Gulf of Aqaba; ultimately providing a range of significant data that will contribute to the reconstruction of more than one millennium of preserved turbidites, flashfloods, and tsunami sedimentary deposits.

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General Session

Poster presentation

The sedimentary record of the last Mesozoic anoxic event (OAE3) in a tropical epicontinental sea

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The Cenomanian–Campanian La Luna Formation is the main source rock in northwestern South America. This formation contains the record of several Mesozoic anoxic events (OAEs), including OAE3. Rocks of the La Luna Formation were deposited in an epicontinental sea that extended from Peru to Venezuela (i.e., the La Luna Sea). In the Coniacian and Campanian, the middle Magdalena Basin of Colombia was the more basinal part of the epicontinental sea and fully portraits the environmental transition associated to the last of the Mesozoic anoxic events (OAE3). The Late Turonian–Early Santonian Galembo Formation records the dawn of OAE3. In this formation, the facies are dominated by wackestones and packstones of foraminifera and inoceramids that often are silicified to different extents. This association of facies is consistent with the deposition of these rocks in an anoxic outer ramp and a sediment–water interface deprived of benthic fauna. The Early Santonian–Late Campanian the La Renta Formation records the end of OAE3. This formation is characterized by the presence of phosphatic beds, and the appearance of the benthic foraminifera *Siphogenerinoides*, grainstones and packstones of fish remains, pelloids, reworked intraclasts, and a moderate diversity of trace fossils (i.e., *Thalassinoides* and *Planolites*). This facies association is consistent with the deposition of the unit in a middle to inner ramp and the local reoxygenation of the sediment–water interface by the influence of upwelling and storm currents. Coeval and similar phosphatic deposits have been recorded in several areas of the southern Tethyan margin suggesting that a regional rather than a local mechanism drove the turnover of the water mass in the southern Tethyan and the Atlantic equatorial. The opening of the southern Atlantic Ocean and changes in the thermal gradient equator to pole could be responsible for such change. At the local scale, the death of the La Luna Sea is marked by the transition from a glauconitic-rich layer of the Tres Esquinas Member to a monotonous siliceous shale of the Umir Formation. This transition is consistent with a still-stand of the sea level, sediment starvation, phosphatization, and dolomitization of allochems, followed by erosion or non-deposition and the fill of the basin without further creation of accommodation space.

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General Session

Poster presentation

Spectacular Alpine mass wasting deposits – a case study from the Lower Jurassic Alpine margin

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Drowning of Triassic Alpine carbonate platforms and reef mounds at many localities goes parallel with synsedimentary block tectonics. One of the most intriguing examples is exposed along the saw-cut wall sections of quarries around the little village of Adnet close to Salzburg (Austria). Onset of tectonics at a former Rhaetian reef mound is indicated by block faulting, tilting and submarine erosion of drift deposits at the slope. Renewed tectonic activity from Late Pliensbachian to Middle Toarcian time created multiple generations of deep reaching vertical tectonic fissures and triggered multiple mass flow events. At the upper and middle slope the so-called Adnet Scheck breccia, which is a special debrite deeply eroding and incising into well-bedded condensed hemipelagic in-situ limestone strata was deposited. Further down-slope the Scheck breccias change into more matrix-rich debrites. Within the basin mudflow deposits, i.e. the so-called pebbly mudstones occur. Tectonic triggers induce various magnitudes of sliding and complex mass transport deposits in the basin. With respect to rheology and transport mode the following conclusions are evident: (1) The down-slope transition of Scheck breccias into clast-rich debrites and finally into pebbly mudstones indicates a drastic change in the flow properties. (2) Cohesive Scheck flows are limited in lateral and down-slope extent, whereas the turbulent pebbly mudstone flows reveal long run-out distances due to hydro-planning. (3) Scoured debris tongues of Scheck type testify deep erosion. The collapse of scour sidewalls is considered to explain enrichment of semi-consolidated sediment slaps and lithified rock blocks at top of the flow. (4) The main driving force in Scheck type flows is a thin muddy layer at the base, whereas the main body tends to freeze and pluck the flow.

Reference

Henrich, R. (2016) Synsedimentary tectonics and mass wasting along the Alpine margin in Liassic time. In: G. Larmarche et al. (eds.), Submarine Mass Movements and Their Consequences, 38, Springer, pp. 449–459.

Theme 3. Deep-marine carbonate depositional systems

General Session

Poster presentation

Usefulness of strontium isotope stratigraphy in slope–basinal carbonate environments (Middle–Upper Jurassic, Mallorca, western Tethys)

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Strontium isotope stratigraphy is a useful technique for dating and correlating strata, particularly when biostratigraphic data or their resolution are limited. Here, we investigate the utility of $^{87}Sr/^{86}Sr$ measured in bulk carbonate mud samples from Middle–Upper Jurassic slope, hemipelagic and radiolaritic deposits from northeast Mallorca. The aim is to assess the reliability of micrite to preserve original seawater $^{87}Sr/^{86}Sr$ ratios in carbonate environments dominated by resedimented material with minor contribution of autochthonous to para-autochthonous beds. We have measured $^{87}Sr/^{86}Sr$ paired to $\delta^{13}C$ and $\delta^{18}O$ isotopes and elemental analysis from mudstone and wackestone interbedded with resedimented carbonates from selected sections. The sampled interval extends from the Lower Bajocian up to the Upper Tithonian, with a sedimentary gap of at least the early Oxfordian. Stable isotopes values range from 1.1‰ to 3.1‰ for $\delta^{13}C_{PDB}$ and -0.2‰ to -3.5‰ for $\delta^{18}O_{PDB}$. These values are consistent with normal marine Jurassic seawater, suggesting no significant pore fluid exchange after burial and carbonate stabilization in closed or nearly closed system during diagenesis where mineral dissolution and reprecipitation were balanced. This suggests that the $^{87}Sr/^{86}Sr$ obtained may potentially be used as a seawater proxy. Strontium isotopes measured from mudstone to wackestone range from 0.7070 to 0.7073, which are consistent with the values of the Middle to Late Jurassic seawater. However, radiolaritic marls and marly limestones show $^{87}Sr/^{86}Sr$ values up to 0.7076, which are slightly more radiogenic than those of the seawater for the time interval considered. This suggests that siliciclastic impurities and silica diagenesis may have deviated the Sr-isotope values toward more radiogenic. The temporal trend of the Sr isotopes plotted with respect to the published Middle–Late Jurassic $^{87}Sr/^{86}Sr$ curve, excepting some outliers, shows a good correlation for the Bajocian, Bathonian and Tithonian units, whereas Oxfordian–Kimmeridgian units are consistently more radiogenic, plotting within the Bajocian or Tithonian values. Terrigenous impurities, carbonate stabilization via exchange with seawater fluids from immediate underlying or overlying units, or burial diagenetic modification may explain this deviation.

Theme 4. General topics in carbonate sedimentology

Special Session 4.1. Special Session in celebration of Maurice Tucker's contribution to carbonate sedimentology: Studies of carbonate rocks and sediments – from sequence stratigraphy and cycles to dolomites and microbialites

Oral presentation

Experimental and modelling results bridge the gap between biological and physical factors ruling the formation of freshwater ooids

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Early work concerning the formation of ooids has been mostly focus in hypersaline milieus, and hence little is known about their genesis in freshwater environments. The microbial role in the formation of the cortex of low-Mg calcite in western Lake Geneva (Switzerland) has been suggested previously, but not demonstrated conclusively. We designed an in situ experiment to mimic the natural process of low-Mg calcite precipitation. A special device was placed in the ooid-rich bank of the lake. It contained frosted glass (SiO_2) slides that acted as artificial substrates to favour microbial colonization. Microscopic inspection of the slides revealed a clear seasonal pattern of carbonate precipitates, which were always closely associated with biofilms that developed on the surface of the frosted slides containing EPS, coccoid and filamentous cyanobacteria, diatoms and heterotrophic bacteria. Further SEM inspection of the samples revealed low-Mg calcite with crystal forms varying from anhedral to euhedral rhombohedra. Liquid cultures corroborate the in situ observations and demonstrate that under the same physico-chemical conditions the absence of biofilms prevents the precipitation of low-Mg calcite crystals. To estimate the relatively influence of physical factors in the formation of these ooids we further used a two-dimensional model to simulate water column currents and their impact on the sediments. These results show that under average meteorological conditions lake currents appear to play a secondary role in the formation and even the distribution of ooids. The outcome of these modelling exercises is hence consistent with a dominant biological component governing today's early stages of ooidal cortex formation. In summary, the combination of experimental and modelling results illustrate that biofilms play a substantial role in low-Mg calcite ooid cortex formation. Combined with microbial cultures under laboratory-controlled conditions, the outcome of our investigation favoured the hypothesis of external microbial precipitation of low-Mg calcite as the main mechanism involved in the early stage of ooid formation in freshwater Lake Geneva. This model has been successfully applied to other sites including marine environments.

Theme 4. General topics in carbonate sedimentology

Special Session 4.1. Special Session in celebration of Maurice Tucker's contribution to carbonate sedimentology: Studies of carbonate rocks and sediments – from sequence stratigraphy and cycles to dolomites and microbialites

Oral presentation

Cold seep carbonates in the Neogene succession of the Crotone Basin (south Italy)

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Within the Crotone Basin of southern Italy, a Neogene cold seep carbonate body, reaching a maximum length of 350 m and a thickness 40 m, crops out. It is dominantly composed of conduit facies with authigenic carbonates filling the previously active gas/fluid escape pipes. In addition, a pavement facies is observed, which consists of early carbonate-cemented bioclastic and siliciclastic sediments commonly colonized by a chemosynthetic macrofauna dominated by articulated and in life-position lucinids bivalves. The conduit facies is characterized by the inward accretion of dark micritic laminae alternating with clear crystalline layers. The micritic laminae show a microbial peloidal to dendrolitic fabric, which commonly incorporates planktonic foraminifera and coprolites. These contrast with the crystalline layers, which are characterized by microspar laminae and sparry crusts made of prismatic zoned calcite crystals. The pavement facies is characterized by laminated microbial boundstones, foraminiferal oozes and hybrid arenites. The foraminiferal assemblage is characterized exclusively by planktonic taxa, which – together with the relative proportion of sandy/silty grains – suggests a deep-water setting with occasional siliciclastic coarser sedimentary flows. The pavement facies shows common brecciation features, possibly indicating the establishment of post-depositional overpressure conditions due to gas/fluid injection. Clasts of breccias show overgrowth by primary fibrous to acicular isopachous to fan-shaped calcite cement. Stable isotopes analysis of all the studied facies reveals negative $\delta^{13}C$ values (-12 to -38‰) and relatively positive $\delta^{18}O$ values (0.83 to 3.4‰), most probably reflecting the destabilization of gas hydrates reflecting a complex mixture of methane and crude oils.

Theme 4. General topics in carbonate sedimentology

Special Session 4.1. Special Session in celebration of Maurice Tucker's contribution to carbonate sedimentology: Studies of carbonate rocks and sediments – from sequence stratigraphy and cycles to dolomites and microbialites

Oral presentation

Structural and stratigraphic controls on carbonate ridge mound development, diagenesis and excess permeability: a Barra Velha Formation, pre-salt case study, Santos Basin

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Ridge mounds represent an important and distinctive depositional environment within the spectrum of Aptian pre-salt lacustrine carbonates that occur in the Barra Velha Formation, Santos Basin, Brazil. Ridge mounds are normally developed in higher accommodation settings, off the flanks of the Sao Paulo High. In seismic data, they commonly show an en-echelon map-view pattern that reflects the underlying fault control on their distribution. The ridge mounds are typified by a range of 2D morphologies. Relief measured from mound crest to toe-of-slope ranges up to several hundred metres and varies along strike.

Well test data indicate that ridge mounds are commonly associated with excess permeability. In borehole image and petrophysical data, excess permeability is linked to both depositional and secondary diagenetic features. These are systematically classified in relation to bedding, faults, fractures, size and orientation. Using a 3D KPSDM seismic dataset, and petrophysical data from 30 wells, quantitative data are extracted in a regular grid (180 m spacing) oriented perpendicular to the structures over 30 km along strike. Parameters including mound height, angle, syn- and post-depositional fault offsets, sediment volume and distance between key stratigraphic markers are extracted. The approach facilitates the integration of well data with the seismic interpretation products in a common data dashboard. Here interrelationships between reservoir quality, mineralogy and seismic parameters could be investigated, quantified and then translated into quantitative geological concepts. The systematic integrated framework and data also allow for the effects of syn- and post-depositional deformation to be isolated and removed.

The workflow reveals along-strike variability of the ridge mound system and understanding of the processes controlling their development, diagenesis (dissolution and silica diagenesis) and so the distribution of excess permeability features. The results show a clear relationship between seismic facies, seismic sequence stratigraphy and diagenetic processes that control the occurrence of excess permeability features. The latter are related to a major lake level lowstand as identified on seismic, with dissolution focused along pre-existing fault and fracture systems.

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Oral presentation

Fluvial barrage tufa as a natural lab for the improving of geotechnical engineering properties of sand by microbially induced calcium carbonate precipitation (MICP)

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In the last two decades one innovative approach to decrease the harmful impact on the natural environment, is to use microorganisms to produce sustainable biomaterials, such as microbially induced Ca-carbonate precipitate (MICP). MICP has been studied for ground improvement to enhance shear strength and stiffness after introducing Ca-carbonate cementing agents into the pores, and for other applications including environmental remediation, production of construction material, improved durability and remediation of building materials, cations removal in wastewater, and carbon sequestration. However, even if MICP could represents a good alternative to the utilization of natural resources and to reduce CO_2 and NO_2 emission of industrial activities, the process produces an inevitable environmental impact as the waste and chemicals involved in lab activities. With the aim to develop a bio-cement for increasing the geotechnical properties of a common multimineral sand, a more sustainable process of MICP was tested introducing the sand in the water flow of a tufa-forming river with active microbial Ca-carbonate deposition. The tufa deposits are covered by a lithifying biofilm composed of a microbial community including autotrophic and heterotrophic bacteria, algae, viruses, and extracellular polymeric substances. Biominerals forming the tufa deposit replace the organic substrates starting with an amorphous phase rich in Ca, Si, and other cations, followed by massive precipitation of fibrous to polyhedral Ca-carbonate crystals and subordinately lamellar/fibrous Mg-clay crystals. During the 16 weeks of the experiment, the biofilm colonized rapidly all the surface of the sand grains, which were gradually encrusted by neoformed Ca-carbonate biominerals showing the same crystal structures and composition of those forming the tufa deposit. Moreover, the sand showed a progressive increase of the internal friction angle from 28.6° to 35.4°, with a trend very similar to MICP lab experiments that used a single bacterial species. This suggests that is possible to use natural Ca-carbonate biominerals, induced by natural microbial communities, for engineering applications with very sustainable procedures.

Theme 4. General topics in carbonate sedimentology

Special Session 4.1. Special Session in celebration of Maurice Tucker's contribution to carbonate sedimentology: Studies of carbonate rocks and sediments – from sequence stratigraphy and cycles to dolomites and microbialites

Oral presentation

The idea of shallowing-upward peritidal parasequences: a thing of the past?

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The understanding of cyclic coastal marine carbonate deposits (i.e. repeated shallow-subtidal to supratidal successions) is dominated by a regressive motif. The shallowing-upward cycles of James (1977), which include both muddy and grainy cycle types, are recognized as parasequences in sequence stratigraphic parlance, being defined as sets of genetically-related strata bounded by flooding surfaces. The underlying assumptions regarding the shallowing-upward-cycle paradigm include: 1) that, on the cycle scale, transgressive deposits are mostly missing as a result of a "lag time" in the carbonate factory following sea-level rise, 2) that tidal flat deposits can prograde basinward for long distances directly into low-energy subtidal environments, creating the muddy cycle motifs of James (1977), and 3) subtidal lagoons can prograde over intertidal to supratidal (i.e. shallower) grainy barriers and shoals, forming the grainy cycles. A global review of Holocene coastal carbonate systems refutes these assumptions. Carbonate barriers and their associated lagoonal deposits can accumulate significant thicknesses in less than 200 years and did so even during the most rapid portion of the Flandrian transgression. Thus, lag time is negligible. Excepting a few sediment-starved areas stabilized by mangroves, most tidal flats form behind carbonate barriers and so cannot prograde directly into open subtidal environments; instead progradation occurs in the form of accreting beach ridges or chenier plains. To our knowledge, no examples of subtidal lagoons prograding over grainy carbonate shoals exist in the Holocene. Furthermore, transgressive deposits form prominent parts of Holocene coastal carbonate cycles. In many cases, recent tidal flat and lagoonal deposits are cycle bases left behind by an overriding landward-migrating transgressive barrier. Open subtidal deposits are as likely to form cycle caps as cycle bases. Therefore, the idea of upward-shallowing parasequences is unhelpful and misleading and should be replaced by the expectation of high-order sequences. Whereas some sequences can masquerade as a parasequence because transgressive deposits have been removed by ravinement, in many cases transgressive lagoonal deposits have been misinterpreted as highstand.

Reference

James, N.P. (1977): Facies models 10: Shallowing-upward sequence in carbonates. In: Walker, R.G. (Ed.), Facies Models. Geol. Assoc. Canada, St. John's, Newfoundland, pp. 109–119.

Theme 4. General topics in carbonate sedimentology

Special Session 4.1. Special Session in celebration of Maurice Tucker's contribution to carbonate sedimentology: Studies of carbonate rocks and sediments – from sequence stratigraphy and cycles to dolomites and microbialites

Oral presentation

The role of viruses in biomineralization of modern carbonate deposits as a key to the past

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In addition to bacteria and EPS, the presence of viruses in modern carbonate settings potentially also have significant roles in mineral precipitation. Viruses are particularly abundant in microbial mats where they likely interact with fungi and other microbes; they are embedded within the cohesive matrix of EPS. Investigations illustrated here are concentrated on biofilms involved in mineral precipitation and the nature of the minerals themselves. Viruses are identified in biofilms associated with modern active travertine, freshwater tufa and stromatolites (travertine sites from the United Kingdom, Slovakia, Italy, Hungary and Turkey; freshwater tufa sites from the United Kingdom, Germany, Italy, Slovakia and Turkey; modern stromatolites from the Bahamas).

The temperature of the water involved ranges from 10^0C to 67^0C with pH between 6.2 and 8.5. The chemical composition of the waters is chiefly a Ca-HCO_3 saturated system with various major and minor element contents dependent on the sampling site. TEM images of the biofilms reveal abundant 80–300 nm size particles that exhibit hexagonal and spherical shapes that are typical of viral capsid-like morphologies. These particles range from non-mineralized to fully mineralized and are commonly included within bacterial EPS. Chemical composition of these virus-like particles indicates that initial mineralization occurs through amorphous Ca–Si rich phases, with less Mg and Al, that replace the organic substrate and eventually evolve to Ca-carbonate with minor silicates. They also contain a variable amount of N and P, even if fully mineralized, that suggest their likely biological origin. Metagenomic analysis of viruses performed on the total genomic DNA extracted from biofilms reveals that most viral strains belong to the bacteriophage families Myoviridae and Siphoviridae. These are naked and tailed viruses with icosahedral-shaped capsids; these features are consistent with the microscopic evidence of mineralized viral particles. It is suggested that viruses are important contributors to biomineralization processes and the formation of carbonate deposits.

These results should stimulate a search for their fossil counterparts in the geological record, back to the earliest evolution of life on Earth.

Theme 4. General topics in carbonate sedimentology

Special Session 4.1. Special Session in celebration of Maurice Tucker's contribution to carbonate sedimentology: Studies of carbonate rocks and sediments – from sequence stratigraphy and cycles to dolomites and microbialites

Poster presentation

Carbonate shoals and coastal barriers are misunderstood

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A review of modern carbonate barrier islands and shoals (e.g., the Bahama Banks, Persian Gulf, the Coorong, Shark Bay, western Florida and the Yucatan Peninsula) shows that their sediment composition and associated early marine and meteoric cementation do not exert a first-order control on their morphodynamics. With the exception of shoals on the margins of rimmed platforms, shoals are genetically related to coastal barriers (i.e., barrier islands and barrier spits with a subaerial carapace), representing either incipient or degraded barriers. The well-known carbonate barrier islands of Abu Dhabi are stable because of a recent sea-level fall, not because of their composition or bedrock core. There is abundant evidence that carbonate barriers migrate landward during transgressions, including during the rapid post-glacial rise of sea level, with migration occurring either by continuous roll-over or by abrupt over-stepping. Drowned fossil barrier islands have been documented on several carbonate platforms and ramps (Persian Gulf, Rowley shelf, and the western Florida shelf), and transgressive lagoonal deposits have been reported from both the Persian Gulf ramp and the southern Australian shelf. Thus, coastal carbonate barriers need not have formed in situ at the highstand shoreline. Any association with bedrock ridges is due to a local coincidence between modern sea level and the elevation of the bedrock high and because the migration of all (both siliciclastic and carbonate) barriers slows when they encounter a topographic step. The deeper Great Pearl Bank shoals are interpreted to be the remnants of former barrier islands that have been left behind when the shoreline jumped to the mainland coast in the later part of the post-glacial sea-level rise. The smaller barriers that occur along the landward sides of many carbonate lagoons also show widespread evidence on ongoing landward roll-over. These findings imply that transgressive successions (lagoonal deposits resting on the sequence boundary and overlain by shelf sediments, the opposite of the classic upward-shallowing facies model) are likely to be much more common than prevailing ideas would suggest. Highly restricted lagoons appear to require the presence of a subaerial barrier; subaqueous shoals rarely impede circulation sufficiently.

Theme 4. General topics in carbonate sedimentology

Special Session 4.1. Special Session in celebration of Maurice Tucker's contribution to carbonate sedimentology: Studies of carbonate rocks and sediments – from sequence stratigraphy and cycles to dolomites and microbialites

Poster presentation

Controls on Neogene carbonate facies and dolomitization on an isolated carbonate platform – the Island of Bonaire

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The Neogene carbonate succession on Bonaire shows complex geometries associated with different depositional and erosional events, which reflect the interaction between eustasy and tectonics. Despite the resulting range of depositional facies and spectacular sequence of terraces, Bonaire is perhaps better known to the geological community, as one of the first locations where reflux dolomitization was applied. Given this historical significance, we re-evaluate the importance and nature of reflux using a previously unstudied set of outcrops on the island. Three major platform stages are defined: 1) an aggradational stage (Middle Miocene) formed of mixed coral rudstone to coralgal packstone, partially dolomitized; 2) a prograding stage (Upper Miocene–Pliocene) consisting of reworked red algal grain/packstone, with pervasive dolomitization, and 3) a flat-topped platform (Pleistocene) with a reefal framework that is not dolomitized. The internal architecture of each of the three platform stages reflects the sedimentation dynamics associated with allogenic controls related to major oceanographic and tectonic events in the region. Observations from the "Seru Grandi" outcrop, part of the prograding platform stage, shows well-defined dolomite bodies extending along clinoform surfaces and become less dolomite-rich with distance below a sub-horizontal erosional unconformity. The dolomite distribution and mineralogical trends suggest early dolomitization driven by fluids moving downwards through a succession, as expected from the reflux model. However, geochemical data and sedimentological context of the dolomites suggest that refluxing fluid was mesohaline (34–52‰) and not a concentrated brine. In addition, our findings suggest that the fluids did not dolomitize the succession uniformly; instead, elongated dolomite bodies were developed within select clinoforms. This variability reflects temporal changes in the flux and chemistry of reactive fluids. Further, downdip trends likely recorded the evolution of magnesium exchange efficiency with distance from the brine source and reactivity of the rock. The Bonaire succession provides a model for understanding isolated carbonate platform development, stratigraphic architecture, facies, and diagenetic changes in an active tectonic setting.

Theme 4. General topics in carbonate sedimentology

Special Session 4.1. Special Session in celebration of Maurice Tucker's contribution to carbonate sedimentology: Studies of carbonate rocks and sediments – from sequence stratigraphy and cycles to dolomites and microbialites

Poster presentation

Characteristics, distribution and origin of Cretaceous dolostones from the western Maestrat Basin (E Iberian Chain)

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The Maestrat Basin, located in the eastern part of the Iberian Plate, recorded a Late Cretaceous basin-wide hydrothermal event, which resulted in the dolomitization of Lower Cretaceous to Cenomanian carbonate rocks. These dolostones, and associated sulphide Mississippi Valley Type mineralizations, have been studied in depth at the eastern part of the basin, in the Orpesa and Morella sub-basins. The present study investigates for the first time these dolostones partially replacing early Aptian platform carbonates of the Villarroya de los Pinares Formation in a western marginal depocentre of the Maestrat Basin named the Galve Sub-basin with the objective of understanding the depositional, structural and diagenetic controls on dolomitization. To this purpose, dolostone bodies were mapped and 509 fractures and faults were measured in the field throughout an area of approximately 25 km^2, 59 samples of dolostones and host rock limestones were taken to characterize rock textures, fabrics and components, and high-resolution orthoimages of the outcrops were captured using a drone. Drone imagery was used to generate 3D outcrop models of the dolostone bodies, which show preserved extents of up to 5 km^2. Dolostones are mainly sucrose and show penetrative, destructive and retentive fabrics exhibiting idiotopic, hypidiotopic and xenotopic textures. Hydrothermal activity during dolomitization is supported by the occurrence of xenotopic mosaics and saddle dolomite filling vacuolar porosity. Vertical control on dolomitization is governed by stratigraphic and stylolitic surfaces (stratabound dolostones), whereas laterally the dolostone bodies are limited by faults and fractures. Four different sub-vertical to vertical fracture orientations have been identified which are NW–SE, NE–SW, WNW–ESE, and NNE–SSW. Associated to fractures, centimetric to decimetric dissolution vacuoles occur. Further controls on dolomitization includes depositional facies (i.e., micrite-dominated textures with lower porosity and permeability are locally not dolomitized). The investigated dolostones were partially calcitized during uplift and exposure. During this later diagenetic stage, poikilotopic calcite cements enveloping idiotopic mosaics developed.

Theme 4. General topics in carbonate sedimentology

Special Session 4.2. Early diagenesis in carbonate sediments

Oral presentation

Impact of storm-induced disturbance on slope diagenetic processes – caught in the act

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Storms have long been recognized as a force that agitates sediments, even in the deep-water. Along continental slopes, downslope and along-slope transport are the conduits of the atmospheric phenomena to the deep water. While such transport events have been studied extensively through sedimentological lenses, their impact on diagenesis remains poorly understood. In March 2020 a tropical storm impacted the Gulf of Aqaba (GoA) in the Red Sea. As a well-established baseline for this locality exists, it offered a unique opportunity to investigate the impact of storm-driven sedimentation events on the diagenetic processes of a hinterland-attached carbonate slope. Detailed sedimentological, mineralogical and porewater analyses were carried out on two sets of short cores collected along a transect from 270 m to 700 m water depths before and after the storm on the western margins of the GoA, which represents a steep slope with a potential for high energy transport events – likely hyperpycnal flows. The cores exhibited a decrease in grain size in the mid-slope water depth and an increase at the base of the slope after the storm, with the top of the core being enriched with terrestrial material. Both Fe and NOx exhibited a marked shift in the aftermath of the storm. NOx concentrations increased in the top 5 cm of all the cores, and the ferruginous zone migrated upwards in both the top and bottom of the slope. We postulate that the storm event remixed the top of the sediment column and infused it with fine material – decreasing both advective and diffusive fluxes across the sediment–water interface. As a result, the porewater trapped in the sediment has developed along the terminal electron acceptor chain. The implications of which would that those hyperpycnal events alter the diagenetic state in underlying sediments. Such impacts should be considered in the interpretation of past slope deposits.

Theme 4. General topics in carbonate sedimentology

Special Session 4.2. Early diagenesis in carbonate sediments

Oral presentation

Recent freshwater stromatolites constructed of primary calcite spar

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The origin of spar and microspar in freshwater tufa stromatolites has been the subject of controversy. Some authors have considered spar to be evidence of diagenesis, and the result of recrystallisation of original micritic fabrics by 'Ostwald ripening' processes. Others have suggested that spar in some tufa stromatolites may be a primary fabric. Here we report some actively growing bulbous stromatolites constructed of spar and microspar in a waterfall setting. Notably these stromatolites are relatively lacking in micrite, particularly in the youngest (very recent) laminae towards the outsides of the specimens where the largest crystals are found. Petrography shows that at least in this case the spar is a primary fabric. In detail, there are at least three different types of laminae in these particular stromatolites. First are distinct c. 50 µm thick organic carbon laminae that comprise mats of *Oscillatoria* cyanobacteria and diatoms. The tufa readily splits along these organic carbon laminae. The next is generally a porous but thicker lamina of micritic to microsparitic tufa. This is in turn overlain by a band of sparry calcite fans, each fan being up to 1 mm thick, with competitive crystal growth commonly leading to columnar crystals towards the top of the band. Fans are commonly progressively darker grey towards their tops, where they are terminated by the black organic carbon laminae. We will here report further field observations combined with optical and electron microscopy, stream chemistry, and organic and isotope geochemistry of the tufa. A model will be proposed that aims to explain how seasonally changing biotic and abiotic factors can cause development of tufa stromatolites constructed of primary calcite spar in waterfall settings.

Theme 4. General topics in carbonate sedimentology

Special Session 4.2. Early diagenesis in carbonate sediments

Oral presentation

Fast rates of microbially-mediated early marine cements

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Authigenic carbonate mineral precipitation in marine sediments drives early marine cementation that has largely been attributed to physicochemical precipitation. However, abiotic precipitation of carbonates cannot fully explain the extent and a growing number of studies recognise the role of microbes and organic matter in early cement formation. Here we report on in vitro experiments in the presence and absence of indigenous microbiota in ooids that assesses the influence of microbial activities on grain fusion and early cementation. Differences in the amount of precipitation in sterile versus non-sterile ooids in these incubation experiments document the biological mediation of early marine cements. Samples with native microbial flora show rapid grain fusion, resulting in the formation of grapestones within 30–60 days. The initial binding of the grains is primarily facilitated by exudates of extracellular polymeric substances and microbial communities acting as catalysts in the formation of micritic bridges, cements and encrusted aggregates. In contrast, sterilised grains remain loose with little crystal formation after 60 days and are devoid of microbes and organic exudates. The near absence of precipitates in the sterilised samples that abiotic precipitation is not the driving force promoting early cements. In contrast, grain fusion is microbially mediated via both a passive mechanisms whereby precipitation, extracellular polymeric substances and cell surfaces function as templates for crystal nucleation and generation of micritic cements, and through active mechanism where biofilm heterotrophs and autotrophs induce chemical alterations of a local environment, facilitating precipitation. The “in vitro” grapestones are similar to native grapestones from Joulter Cays with intergranular areas infested with extracellular polymeric substances, microbes, micritic cements, amorphous calcium carbonate nanograins and micritised outer surfaces. These similarities suggest that incubations with native flora follow similar mineralization mechanisms as in the natural environment. This study underscores that microbially mediated cementation can occur at fast rates and that firmground to hardgrounds and slope stabilisation take place shortly after deposition of carbonate grains.

Theme 4. General topics in carbonate sedimentology

Special Session 4.2. Early diagenesis in carbonate sediments

Oral presentation

Susceptibility of aragonitic biominerals to diagenetic alteration

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Biocarbonates are archives of useful geochemical information for reconstructing past environments. Aragonite is a metastable mineral phase under Earth's surface conditions and transforms into calcite during diagenesis. The reliability of aragonitic skeletons as geochemical proxies can be compromised when this transformation happens. However, the diagenetic alteration can be very subtle, especially when it takes place at low temperature, and bioaragonite can undergo many microstructural changes prior to transforming into calcite. Therefore, safely using biocarbonates as geochemical proxies requires to understand the nature of these early diagenetic changes, how they are modulated by the specific features of the aragonite skeleton and what degree of diagenetic overprint can derive from them. Recent studies have shown that the hydrothermal alteration of aragonitic skeletons at high temperatures (175°C) leads to the replacement of the original aragonitic microstructures by crystals of abiogenic calcite through a series of intermediate steps. This work aims to shed light on these intermediate stages of diagenetic alteration. To do so, we conducted long term (4 and 6 months) experiments where diagenetic-mimicking fluids interacted at 80°C with the aragonitic skeletons of three marine organisms: the bivalve *Arctica islandica*, the gastropod *Haliotis ovina*, and the coral *Porites* sp. The pristine and altered microstructures were analysed with EBSD, SEM, AFM, XRD and TGA. Our results depict the hydrothermal alteration of the aragonitic biocarbonates as a complex multi-step process whose kinetics is strongly influenced by mineralogical, textural, microstructural, and chemical parameters. The characteristics of the alteration varied significantly depending on the original microstructure of the skeletons. Thus, the coral *Porites* sp. remained unaltered even at the nanoscale after 6 months of alteration. In all other microstructures, the alteration began with the destruction of the organics followed by the formation of porosity, which was then filled with abiogenic aragonite. Ultimately, biogenic and abiogenic aragonite transformed into calcite. Our findings provide insights on the primary features that influence the susceptibility of biocarbonates to resist diagenetic overprint.

Theme 4. General topics in carbonate sedimentology

Special Session 4.2. Early diagenesis in carbonate sediments

Oral presentation

Early diagenetic processes on resedimented carbonates on the sea floor: lessons learned from the Maldives and the Midland Basin, Texas

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Over the last several decades, many diagenetic processes occurring on the seafloor surrounding carbonate platforms have been detailed studied. However, recent publications have demonstrated that many of those processes are still poorly understood, especially in the slope, toe-of-slope, and basin floor, where platform-derived material significantly affects how those deposits respond to diagenetic changes. In addition, those sediments commonly interact with oceanic bottom currents producing an effective flow zone. The bottom currents are significant since they interact with the seafloor to create a previously unrecognized advective flow mechanism in the shallow subsurface, herein defined as "current pumping". This mechanism triggers several diagenetic processes, including dissolution, calcite cementation, and dolomitization. The initial focus here is on the abiotic physical and chemical events producing diagenetic changes, however, microbial activity may indirectly influence these processes. The results of two studies from different geographic and age localities show a very similar diagenetic trend. First, different diagenetic processes were studied from five IODP 359 sites from the Maldives using geochemical and petrographic data. The dataset originates from the Neogene age Kardiva platform margin, slope, toe-of-slope, and drift deposits filling the Maldives' inner sea. Second, the Happy Spraberry field, located on the Midland Basin's eastern flank, contains Permian age platform-derived materials reworked and resedimented into the toe-of-slope environments. Both examples show preferential dissolution, cementation, and dolomitization from seawater-derived fluids. Those fluids were pumped into the shallow subsurface creating an advective zone delivering Mg for dolomitization, undersaturated waters for dissolution, and remobilizing Sr from aragonite to calcite and other cements. We learned that the most significant diagenetic overprint occurred very early in the evolution of the successions preserving the early changes (dissolution, cementation and dolomitization) during the subsequent geological history. The results presented here highlight the significance of understanding early diagenetic processes and their hydrodynamic drivers.

Theme 4. General topics in carbonate sedimentology

Special Session 4.2. Early diagenesis in carbonate sediments

Oral presentation

Controls on formation and early diagenesis of gypsum microbialites at lake Afdera (Ethiopia)

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The Danakil Depression, situated in the northern part of the Afar triple junction, is part of an active rift zone associated to the break-up of the Afro-Arabian plateau. The hypersaline lake Afdera is situated in the southern part of the Depression. Gypsum actively precipitates within the lake, but especially around Franchetti Island, a volcanic island in the central part. Gypsum deposits are present as crusts, concretions and meter-sized mounds composed of cauliflower structures and laminated gypsum deposits alternating with microbial mats. In this study we investigate the formation of gypsum and the role of microbial films in the precipitation and early diagenesis of micro-scale fabrics. This study uses a combination of standard sediment petrological techniques, cathodoluminescence microscopy, fluorescence microscopy, XRD and SEM to characterize the gypsum deposits and their evolution trough time. Samples were collected along two proximal – distal transects (island – open lake) during field expeditions in 2017 and 2019. Preliminary results show a correlation between the different morphologies and micro-scale fabrics along the studied profiles. Mineralogical analysis evidence a distinct gypsum/anhydrite transition across the transects. SEM images evidence the close spatial relationship between gypsum crystals and biofilms. This study provides new insights into the characteristics and formation of the Lake Afdera's gypsum microbialites. Overall, further investigations will contribute to the characterization of understudied gypsum deposits in the geological record of which the formation mechanisms are often debated and poorly understood.

Theme 4. General topics in carbonate sedimentology

Special Session 4.2. Early diagenesis in carbonate sediments

Oral presentation

Phanerozoic trends in early diagenetic aragonite dissolution

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The differential participation of different calcium carbonate polymorphs in early marine diagenesis due to their thermodynamic stability is well known. Aragonite is less stable than calcite and prone to dissolution in the distinct redox conditions caused by microbial decay of organic matter during the early stages of burial. The dissolved calcium carbonate can reprecipitate as calcite cement at a relatively short distance, thus resulting in layers of calcium carbonate export (i.e. marl) and layers of calcium carbonate import (i.e. limestone). The implications for the interpretation of carbonate rock sequences are highly debated, and the potential influences of this redistribution of carbon and other elements on global geochemical cycles remains underexplored. The intensity of this early diagenetic carbon redistribution is largely driven by the proportion of aragonite in the original sediment. As the seawater Mg/Ca ratio and temperature strongly impact inorganic calcium carbonate mineralogy and skeletal mineralogy (at least before the Jurassic), we expect that the intensity of the redistribution varies throughout the Phanerozoic with seawater Mg/Ca and temperature, i.e. aragonite–calcite sea conditions. This study aims at evaluating the intensity of diagenetic aragonite dissolution and calcite precipitation through the Phanerozoic by comparing diagenetically inert Al/Ti ratios of limestone–marl alternations from published datasets of limestone–marl alternations. Results will be interpreted in the context of the available shelf area and palaeotemperature.

Theme 4. General topics in carbonate sedimentology

Special Session 4.2. Early diagenesis in carbonate sediments

Oral presentation

Evaluating diagenesis in peritidal carbonates: a case study from southeast Indiana, USA

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The evaporative reflux model is frequently invoked to explain dolomitization of peritidal carbonates. Some recent studies suggest, however, that dolomitization via evaporative fluids may not be as common as previously thought. Here, the dolomites of the Upper Ordovician (Katian) of southeast Indiana, USA (Richmond Group – Saluda Fm) are investigated. Previous work suggests that these dolomites formed via hypersaline fluids in a restricted lagoonal setting. Other work argued that dolomitization occurred after deposition of the overlying formation in mixed meteoric-marine fluids. The current study aims to test these models through integration of high-resolution mineralogic, isotopic, petrographic, and geochemical datasets.

A total of 6.4 meters of the outcrop was sampled at 10 cm intervals (N=66) over 4 vertical transects. Mineralogical data indicate the Saluda is primarily composed of Ca-rich, poorly ordered dolomite and low-Mg calcite. Dolomite stoichiometry and cation ordering is nearly constant with depth, averaging 46.34 ± 0.15 mol% $MgCO_3$ and 0.43 ± 0.08, respectively. Dolomite abundance correlates with depositional texture such that it is more abundant in mud-dominated facies (i.e., mudstones) and less abundant in wackestone-packstone facies. Petrographically, the fabric-destructive dolomites are coarse crystalline (30–120 µm) planar-e. Low Mg-calcite is observed as both microcrystalline calcite that predates the dolomite and as a blocky calcite cement that postdates the dolomite. Stable isotopic analyses show that $\delta^{18}O_{dol}$ is higher (-3.09 ± 0.34 ‰ VPDB) than $\delta^{18}O_{carb}$ (-3.74 ± 0.46 ‰ VPDB), a difference interpreted to reflect mineralogical fractionation between calcite and dolomite. The $\delta^{18}O_{dol}$ values are similar to those expected for Upper Ordovician marine dolomites, suggesting dolomitization likely occurred very early and was driven by marine fluids. Further, the lack of downward vertical mineralogic and isotopic trends suggests dolomitization via downward refluxing brines is not likely.

Theme 4. General topics in carbonate sedimentology

Special Session 4.2. Early diagenesis in carbonate sediments

Oral presentation

Hypersaline origins of Bahamian dolomites: evidence from new geochemical proxies

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Although dolomite is found as an early diagenetic mineral in Holocene and Pleistocene sediments throughout the world, there has been a distinction between those dolomites formed in arid environments associated with evaporite minerals, and those present in less extreme climates with higher amounts of meteoric precipitation. In this presentation we present evidence that contrary to previous proposed mechanisms, that some of the Bahamian dolomites may also be formed under the influence of elevated salinity brines. In the Bahamas, rocks of Pliocene and older age have frequently been subjected to massive dolomitization with the principal hypothesis being that the dolomitization was induced by normal seawater being circulated through the carbonate precursors. However, several lines of evidence derived from changes in petrography, sedimentology, and geochemistry suggest that the dolomites are related to repeated small changes in sea level. We suggest that during periods of lower sea level, hypersaline ponds develop upon islands, similar to those observed throughout the Bahamas today. The warm dense fluids which are present in the hypersaline ponds contain high amounts of organic material that degrade through aerobic and anaerobic oxidation thus elevating alkalinity and are thus producing a solution highly conducive to the formation of dolomite. The fluids reflux through the underlying sediments and interact with underlying seawater causing the precipitation of dolomite as well as dolomitization of the precursor sediments. Repeated small oscillations of sea level produced a number of sequences of dolomite, each overlain by sedimentological evidence of the presence of shallow hypersaline ponds. The geochemical signature of this process yields carbonates with elevated temperatures, as measured using clumped isotopes near the top of the sequence with elevated $\delta^{18}O$ values, high trace element concentrations derived from atmospheric dust and Ca and Mg isotopes representative of open system alteration. Further from the exposure the sequence shows evidence of more closed system diagenesis, before transitioning to a similar underlying sequence. Deposition of such sequences are repeated numerous times with final dolomitization associated with later movement of seawater.

Theme 4. General topics in carbonate sedimentology

Special Session 4.2. Early diagenesis in carbonate sediments

Oral presentation

Study of two carbonate seepages from Lower to Upper Miocene Hikurangi active margin (New Zealand, North Island)

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The study focuses on the analysis of tubular carbonate concretions outcropping in two areas in the New Zealand Hikurangi active margin: the Akitio syncline and Cape Turnagain. This work intends to enlighten the role of pipes involved in fluids circulation and to compare them from two former basins having evolved from lower/middle Miocene (Akitio) and upper Miocene (Cape Turnagain). In both cases, the host rock is composed of very fine-grained muddy sediments (calcareous mudstones) containing a lot of framboidal pyrites, quartz, feldspar and very few and poorly diversified fauna indicating paleoenvironmental stressed depositional settings. Concerning the tubes themselves, they differ drastically on a morphological point of view: They are cylindrical and very large in Cape Turnagain, whereas they are rugose and far smaller in Akitio. In the Akitio syncline, the biggest tubes are characterized by a lot of late cross-cutting fracturation and brecciation stages, filled by softly deformed monomict fluidized muds. More-over, association of framboidal pyrite, authigenic quartz and bitumen lining was observed in pre-fracturation/pre-injection sequence. In the case of Cape Turnagain, diagenesis sequence is highlighted by complex dissolution/cementation stages (early calcite/dolomite cementation, framboidal pyrite, aragonitic crust). Neither late fluidized infills were observed nor late fracturing. 80 stable isotope ($\delta^{18}O/\delta^{13}C$) analysis were carried on micro-samples. All these data are completed by cathodoluminescence analysis associated to major and minor chemical analysis (SEM/EDS elemental measurements) In Akitio basin, two main origins of carbonate cements and mud infilling were revealed: anaerobic oxidation of microbial CH_4 and temperature increasing in the later stages. The building of tube framework took place in early reducing environment followed by later infilling of the tubes, using the pre-existing "plumbing system". In Cape Turnagain, early dissociation of gas hydrates below the sea floor and reduction of CO_2 as a by-product of methanogenesis are involved (Nyman, 2009). Finally, tube formation differs strongly between these two areas: they were both differently early built and they moreover experienced hotter late fluid circulation in Akitio than those of Cape Turnagain.

Theme 4. General topics in carbonate sedimentology

Special Session 4.2. Early diagenesis in carbonate sediments

Oral presentation

Gypsum-driven dedolomitization: insights from reactive transport modelling

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Dedolomitization is a process where dolomite is converted to calcite by calcium rich fluids. Although dedolomites can form in various diagenetic environments, the most commonly invoked setting is at shallow burial depths where meteoric waters encounter gypsum. The dissolution of gypsum increases the calcium concentration of porewaters, shifting the Ca/Mg ratio of the fluid to favour replacement of dolomite by calcite. Understanding this process is important because it is often associated with a lowering of porosity and permeability, compared to the precursor dolomite. Conversely, the dissolution of gypsum increases porosity and permeability, which over time may lead to cavity development followed by collapse. To better understand the relationship between gypsum dissolution and dedolomitization we built reactive transport models using TOUGHREACT and parameterise simulations using modern hydrochemical data from Qatar. Storm recharge waters from surface depressions are used as the input fluid and the composition of fluids after reaction with gypsum and dolomite host rock is compared to that of groundwaters from an area where dedolomitization is currently occurring. This approach allows the validity of the models and inherent assumptions to be evaluated. From this foundation, we assess the role of the host rock mineralogy, fluid chemistry, temperature, flow rate and pCO_2 in controlling rates of gypsum dissolution and dedolomitization. Results suggest that the degree of undersaturation of the initial fluid with respect to gypsum determines the mass of dedolomite produced per volume of fluid. Therefore, the fluid flux is also closely linked to the dedolomitization rate. Changing the host rock from distinct layers of gypsum and dolomite to mixed gypsum and dolomite increases the rate of both gypsum dissolution and dedolomitization. Increasing the temperature results in a small increase in gypsum dissolution whereas the effect of pCO_2 is negligible. Complete dedolomitization of the host rock leads to a matrix porosity loss of ca. 10%. After all the dolomite has been converted, calcite may continue to precipitate but at a much slower rate than when dolomite dissolves.

Theme 4. General topics in carbonate sedimentology

Special Session 4.2. Early diagenesis in carbonate sediments

Oral presentation

Early marine carbonate diagenesis and bedding planes: why is there so much misinformation in the literature?

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Bedding planes are fundamental features of sedimentary rocks. A survey of definitions of the term, even some published very recently, shows a fixation with depositional surfaces, breaks in sedimentation, erosional origins, all relating to primary depositional processes. What these definitions ignore is that for decades it has been known that bedding surfaces, especially but not wholly in carbonate rocks, can be partly or wholly diagenetic. Although bedding planes caused by burial processes such as compaction and pressure solution had been identified, it was Bathurst in 1987 and 1995 who made a compelling case that very early calcite cementation, likely relating to aragonite dissolution, was responsible for providing the mechanical heterogeneities that in many cases burial processes later enhanced to produce bedding planes. More recently, the processes of very early transformation of aragonite at very shallow burial depths in marine pore waters have become better understood; as has their role in the formation of diagenetic bedding and related bipartite lithologies (such as limestone–marl-alternations), some types of hardgrounds, and secondary carbonate mudrocks. Diagenetic bedding is especially ubiquitous in low energy offshore marine successions and is most readily seen in mixed clastic–carbonate successions whereby the limestone beds are commonly purely diagenetic in origin, and so are the bedding planes. The critical point is that these carbonate bounding surfaces formed within the sediment, are therefore not depositional surfaces, and do not directly reflect breaks or changes in sedimentation; thus many bedding planes are purely diagenetic in origin and are not primary depositional features. Such a distinction between depositional and diagenetic bedding is fundamental to how we interpret sedimentary strata and it seems that most currently circulating definitions ignore the facts. Here the different mechanisms of formation of bedding planes are summarised, their range and potential to form in different depositional environments evaluated, and how understanding these types impacts on how we decipher the geologic record.

Theme 4. General topics in carbonate sedimentology

Special Session 4.2. Early diagenesis in carbonate sediments

Poster presentation

Coring technique choices in scientific ocean drilling affect the observed lithification and physical properties in marine carbonate sediments

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The International Ocean Discovery Program (IODP) uses an advanced piston corer (APC) in soft sediments, and an extended core barrel (XCB) in firm sediments. Within a single hole, the operator switches from APC to XCB once the formation is too hard or cohesive. The coring tool exchange typically occurs around the same depth in adjacent holes of the same site. However, during IODP Expedition 356, the coring tool switch occurred at different depths: IODP Sites U1463 and U1464 are marked by a stratigraphic interval (>25 m thick) that was XCB cored in one hole, and APC cored in other holes. Shipboard scientists remarked that APC-cored sediments were unlithified or partially lithified, while XCB-cored sediments were fully lithified. This difference in sedimentological description of the same formation seems to be an effect of coring technique. To provide further insight, we assessed the physical properties, downhole wireline logging data, scanning electron microscope (SEM) images, and micro computed tomography (μCT) scans of those intervals. XCB cores are characterized systematically by lower bulk density, higher porosity, and higher P-wave velocity compared to APC cores. Downhole logging data suggests that the original P-wave velocity of the formation is better preserved in XCB cores, despite the typical biscuit-and-gravy artefact. In conjunction with SEM and μCT images, we conclude that the APC tool destroyed early lithification by breaking cements between individual grains. Moreover, μCT images reveal denser packing and smaller pore volumes in the APC cores. These sedimentary changes likely occur when the APC pressure wave passes through the sediment. The destruction of grain-to-grain cements provides an explanation for the significantly lower P-wave velocities in APC-cores. Interestingly, the gravy sections in XCB drilled cores mimic the destruction of early lithification and reduction of pore volume. We conclude that APC remains the tool of choice for recovering soft sediments, especially for paleoclimate purposes. However, for the study of lithification and early diagenesis, XCB biscuits provide a more representative sample of the formation.

Theme 4. General topics in carbonate sedimentology

Special Session 4.2. Early diagenesis in carbonate sediments

Poster presentation

Laboratory early diagenesis of carbonates: an experimental approach of geological processes, and their role on aquifer development

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Observations of carbonate sedimentary successions show the presence, under emersive surfaces, of highly porous and permeable levels forming well-developed aquifers. So, it can be assumed that these levels have undergone an episode of early diagenesis in a meteoric environment. This type of event would have a deterministic role in the formation of aquifers in carbonate systems. To verify this hypothesis and further understand the phenomenology of early diagenesis on aquifer properties, an experimental set-up has been created to reproduce features (pores, cements...) of early diagenesis from natural aragonitic sands. A particular attention is paid to aragonite particles dissolution and cement calcite recrystallization, to the microstructures thus produced, and to the experimental parameters favouring these reactions. Two types of tests are performed. On one hand, samples of water-saturated aragonitic sand are placed in autoclaves and heated to 200°C for several days to several weeks. On the other hand, we use a new experimental apparatus: an oedometric cell for stress field onto the sand, heat up to 100°C, and circulation of a fluid in the porous medium. Two main parameters are investigated: the nature of the sedimentary grains which undergo diagenesis, and the particle size distribution. Our initial results indicate that increasing the specific surface area of grains by grinding does not favour the aragonite–calcite transformation. On the contrary, it tends to reduce it. More, the use of previously sterilized grain tends to greatly reduce mineralogical transformations. Finally, it seems that the very structure of the oolites strongly favours the aragonite dissolution reactions.

Theme 4. General topics in carbonate sedimentology

Special Session 4.2. Early diagenesis in carbonate sediments

Poster presentation

Hydrothermal alteration of microcrystalline dolomite concretions from the Permian continental red beds

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Fine-grained sedimentary carbonates are important climatic archives. Recognizing the effects of post-depositional modification of such rocks is, therefore, crucial for the assessment of fidelity of these archives. Early-diagenetic carbonate concretions, typically also composed of microcrystalline carbonate and preserving original depositional fabric, are analogously developed to fine-grained sedimentary carbonates. Here we present such concretions from the Permian continental red beds from Poland, which were affected by hydrothermal activity related to shallow intrusions. We have performed mineralogical (XRD), petrographic (polarizing microscopy, CL, SEM), and isotopic ($\delta^{13}C$–$\delta^{18}O$) investigations in order to check for potential effects of hydrothermal alteration of carbonate material. The concretions are laminated, concentrically banded, and contain septarian cracks filled with saddle dolospar indicating elevated temperature of fluids circulating within the sediments after concretionary growth. The concretion core is composed of microcrystalline, non-planar, homogeneous, Fe-rich dolomite, apparently not recrystallized. Stoichiometry and size of dolomite crystals increase towards the concretion margin, which is observed in the concentric banding. The recrystallized dolospar is developed as planar, zoned, rhombohedral crystals, which appear also in the core, but their occurrence is limited to coarser-grained laminae and margins of the septarian cracks. Recrystallization is also reflected in $\delta^{13}C$ and $\delta^{18}O$ values, FWHMs of XRD peaks, and amount of Fe in dolomite, which drop at the margins. The concretions must have been pervasively heated up, but recrystallization occurred only at their margins and along more permeable structures, where fluids could have flown through. This shows that the abundance of hot fluid, not their temperature, is the key parameter driving carbonate recrystallization. Interestingly, unaltered dolomite exhibits uniform CL, whereas recrystallized dolomite shows heterogeneous CL pattern following crystal zoning. Therefore, contrary to what is commonly perceived, CL zoning concordant with crystal habit, is not necessarily an evidence of primary origin of dolomite.

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Theme 4. General topics in carbonate sedimentology

Special Session 4.2. Early diagenesis in carbonate sediments

Poster presentation

Automated mineral analysis of Holocene reef rocks

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Early marine diagenetic processes are affected by a variety of physical, chemical, and biological processes that can alter their composition and properties. The processes cause change on sub-micrometre scales in the presence of microbial metabolism and by-products. Compared to later stage meteoric diagenesis that can be more pervasive in effect but still results in fabric selective textures and heterogeneity at micron to cm scales. Diagenetic analyses inform biogeochemical cycles, lithification and alteration which affects the reliability of the geochemical data used for paleoenvironmental and isotopic dating to minimise geochemical anomalies. Electron microscopy (EM)-based techniques have been useful as tool to visually demonstrate textures at high resolutions and indicate mineralogy with elemental analysis but have lacked the broad perspective and speed of light microscopy. New-generation EM offers high-quality chemical composition data maps, with the potential to generate mineral and textural information over comparable spatial scales. Core material from the Southern Great Barrier Reef, was used to explore the utility of automated mineral (AM) analysis in characterizing the microtextural, elemental, and mineralogical features in Holocene reefs. High-resolution, large-area mapping of carbonate minerals (down to 0.5 µm pixel spacing) was performed using a TESCAN Integrated Mineral Analyzer (TIMA) Field Emission Scanning Electron Microscope at the Central Analytical Research Facility, QUT (Brisbane, Australia). Multiple EDX detectors have facilitated rapid collection of spectral data at micron resolution (~1.5 µm spacing) with minimal surface damage. Collected spectra were used to confirm the presence of elements and mineral phases. Custom queries of the elemental data with proprietary software (TIMA-X) enables subtle phase differentiation of carbonate mineral phases including aragonite, calcite, low-magnesium calcite, high-magnesium calcite, and dolomite. Mineral phases were verified with Raman spectroscopy (Renishaw inVia QONTOR). This study illustrates relatively subtle microtextural and mineralogical features in carbonate rocks mapped with AM and as tool to target sample regions for further microanalytical techniques.

Theme 4. General topics in carbonate sedimentology

Special Session 4.2. Early diagenesis in carbonate sediments

Poster presentation

Early post-sedimentary multi episodic fluid flow into post-rift Cenomanian limestones in the NE of the hyperextended Basque–Cantabrian Basin margin, western Pyrenees

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The diagenetic studies of syn- to post-rift deposits from hyperextended basin margins can play a key role in the comprehension of fluid circulation into post-rift carbonate platforms. Field and petrographic observations of Cenomanian shallow marine limestones of the northwest of the Bortziriak Palaeozoic massif, NE of the hyperextended Basque–Cantabrian Basin, indicate early diagenetic fracturing, fluid-flow, sediment infill, dissolution, neomorphism and cementation processes. Fluid-flow resulted in an increase of the pore hydrostatic pressure and subsequent brecciation. That early fracturing and increase in permeability allowed the percolation, transport and deposition of reddish micrite and calcarenitic sediment within fracture cavities, as well as the precipitation of radiaxial-fibrous and blocky calcite cements. Additionally, selective neomorphism of rudist shells and corals was also intense. Based on petrological cross-cutting relationships and cathodoluminescence, sequential infillings and cements are recognized. $^{87}Sr/^{86}Sr$ and $\delta^{18}O$–$\delta^{13}C$ data from host limestone, rudist shells, infillings and cements suggest that multiepisodic fluid and sediment circulation processes acted early in the phreatic marine realm. Thereafter, fluids mixed with deeper fluids with higher $^{87}Sr/^{86}Sr$ and more negative $\delta^{18}O$–$\delta^{13}C$ stable isotopes, probably due to the interaction with deeper (Palaeozoic?) rocks. Finally, tectonic stress derived from the Alpine inversion generated pressure dissolution seams (stylolites) and sets of calcite veins, which cross-cut prior features. All these data suggests the existence of an early post- sedimentary fluid circulation system in the marine phreatic realm, which evolved towards basinal fluid circulation before the Cenozoic inversion of the basin.

Theme 4. General topics in carbonate sedimentology

Special Session 4.3. Non-marine and marine carbonate factories and their expressions in sequence stratigraphy

Oral presentation

Is sea level driving greenhouse carbonate sedimentary systems?

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Most studies of carbonate sedimentary systems are funded on sequence stratigraphy, especially for characterizing stacking patterns and reconstructing stratigraphic architectures. The keystone of these sequence stratigraphic studies consists in the spatial correlation of the “Relative Sea Level” (=accommodation) curve, often simplified as the sea-level curve. Other controlling parameters including subsidence and carbonate production remain difficult to constrain at local including carbonate reservoir scale from most available sedimentary records and dating. Sea-level patterns, which are cyclic by nature, are usually applied to characterise cyclic carbonate sequences. If sea-level signals are consistently recorded during the Pleistocene–Holocene icehouse period, the sedimentary record of sea-level fluctuations during a greenhouse period are not well constrained. The definition of transgressive and regressive cycles on continuous outcrops of Urgonian carbonates has shown reversed correlations for the same time units (Early Cretaceous, Provence, SE France). This is induced by variations in carbonate production along the proximal–distal profile, which directly influences the record of sea-level fluctuations. In this context, quantitative sequence stratigraphy including forward modelling approaches are required to better support interpretative stacking and accommodation patterns. More generally, the response of carbonate sedimentary systems in terms of productions, substratum movements and preservations is not linear or constant in space and time to the variation of accommodation. This aspect limits the deconvolution of eustatic variations from the analysis of log sections at depth and implies testing many hypotheses. In this context, global trends can support subsidence and carbonate factory predictions to contextualise any sequence stratigraphic interpretation, in particular during greenhouse periods during which sea-level control is uncertain. During the icehouse Oligo–Miocene period showing a unique sea-level evolution, diverse stratigraphic architectures developed across the different paleoclimatic belts. By contrast, carbonate architectures of greenhouse periods of e.g. Eocene, Early Cretaceous and Late Jurassic show weaker global variabilities.

Theme 4. General topics in carbonate sedimentology

Special Session 4.3. Non-marine and marine carbonate factories and their expressions in sequence stratigraphy

Oral presentation

Role of microbial communities in carbonate precipitation in river systems and their efficiency in CO_2 capture and storage

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In the Burgundy Franche–Comté region (France), many rivers are the seat of an important carbonate production. Long considered to be the result of abiotic processes attributed to chemical precipitation, carbonate concretions ("tuffs") are nonetheless made up of an important microbial component, implying an active role in the formation processes of these carbonate deposits. These rivers are mainly fed by karstic springs which allow an efficient recharge of the system, in particularly in Ca^{2+}, HCO_3^- and other ions. The carbonate components are organized in built structures and are defined as oncolites, capping crusts and dams macrofabrics and are not homogeneously distributed along the rivers. The mesofabrics are marked by an alternation of porous and dense laminae also observed in the microfabrics with an alternation of cements and peloids rich in microbial filaments and plant remains. The different morphologies seem to show an important periodicity in the mineralization and their establishment appears to be controlled by a large number of factors that may be physical, chemical and biological. Changes in climate and watershed properties and topography are the main drivers for carbonate precipitation vs. dissolution. While the functioning of microbial systems and their role in carbonate precipitation are well constrained, many gaps remain in the quantification of the volumes of carbon that can be stored and the kinetics of mineralization. Recent studies suggest that the volumes of these deposits are often poorly known and underestimated relative to many streams, whereas approaches that focus on the ability of organisms to induce carbonate precipitation appear to be of great interest in the processes of CO_2 capture and storage. This study focuses on two very mineralizing rivers, the Ru Blanc, located in the Côte d'Or department and Marangea, located in the Jura department (France). The first objective is to determine the parameters that influence the production of carbonates in natural systems with a focus: (1) on their biotic versus abiotic composition; (2) their morphologies and (3) their specific spatial distribution along a small river. The second one is to estimate the volume of the main carbonate structures defined as tufa dams and capping crusts and highlight the efficiency of this carbonate factory.

Theme 4. General topics in carbonate sedimentology

Special Session 4.3. Non-marine and marine carbonate factories and their expressions in sequence stratigraphy

Oral presentation

Microbialite development and preservation in lakes

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Mapping of carbonate buildups in different lake settings enables a comparison of their specific spatial distribution, morphology, and biotic/abiotic origin. The morphology, size and distribution of carbonates are predominantly governed by short- to long-term water level fluctuations, geomorphological heritage, fault-induced processes, groundwater seepages, and substrates. A review of lakes that have been studied in this regard shows a paleoshoreline distribution with some microbial-rich buildups resulting from climate-induced lake level variations. However, the occurence of columns and complex domes made up of biotic/abiotic carbonates appears related to the groundwater influx. Among the selected lakes, Lake Dziani Dzaha is a thalassohaline crater preserved in Mayotte (Western Indian Ocean) with microbialites diverse in form, mineralogy, and biotic composition resulting from complex interactions between functionally diverse microbial communities. They mainly develop along the shoreline, except for some columns, that form around reeds and degassing locations. A similar pattern is observed in Pyramid and Winnemucca Lakes (Great Basin, USA) during the Pleistocene–Holocene periods and in the Limagne Basin (France) during Oligocene–Miocene. In both settings, small-scale buildups develop along the shorelines, whereas large columns are determined by fault-controlled and spring-related groundwater influxes at the termination of fan-shape delta. The contrast in size and distribution of the carbonate buildups at the scale of the Great Basin and the Limagne Basin show that groundwater chemistry influences the biotic/abiotic carbonate precipitation by locally increasing the Ca^{2+} and HCO_3^- concentration. The importance of ion availability (Ca^{2+}, Mg^{2+}) in carbonate precipitation is more easily investigated in a closed basin, especially when the ion pool remaining in the basin and HCO_3^- being primarily in equilibrium with atmosphere and can be exchanged as CO_2. The Ca^{2+} availability appears to be a limiting factor for carbonate precipitation whether transported by surface streams, or by large groundwater influxes, and occasionally substituted by Mg^{2+}, e.g., in volcanic lakes. Thus a complexity of factors are involved in microbialite formation that requires a multidisciplinary approach.

Theme 4. General topics in carbonate sedimentology

Special Session 4.3. Non-marine and marine carbonate factories and their expressions in sequence stratigraphy

Poster presentation

The classical Santonian carbonate platforms of Les Collades de Basturs (southern Pyrenees) revisited with drone imagery

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Upper Cretaceous (Santonian) carbonate platforms are superbly exposed along Les Collades de Basturs, in the southern limb of the Sant Corneli Anticline (Catalonian Pyrenees). This carbonate succession, which belongs to Les Collades Member, crops out for 4.5 km NW–SE and up to 0.6 km NE–SW. Les Collades Mb is underlain by Coniacian–Santonian marine limestones of the Montagut Mb and is unconformably overlain by Maastrichtian siliciclastics of the Areny Formation. The palaeontological content and sedimentary evolution of this Santonian sedimentary record has been studied since the 80's. New drone technology permits nowadays to reach new heights helping to map outcropping rock facies, stacking patterns and stratal terminations in greater detail. For the present study, a high-resolution 3D model was generated from the orthoimagery acquired from the drone. This model was used on site for line drawing of stratigraphic surfaces, as well as for mapping facies heterogeneities and structural features with the aim to provide detailed facies architecture and sequence stratigraphic analyses for these platform carbonates. 890 logged meters divided into seven representative stratigraphic sections of up to 252 m thick were measured to support the 3D facies architecture model. The investigated succession can be largely subdivided into three episodes of carbonate platform development which pass laterally and upwards (after drowning) to distal nodular marly limestones and marls rich in level-bottom coral communities and *Lacazina*. The platform carbonates show a marked cyclicity with alternating coral–rudist (marly-) limestone beds, hippuritid biostromes and skeletal grainstones, and overall aggradational and progradational stacking patterns and thus are interpreted as highstand normal regressive units. The general progradational trend of the carbonate systems is towards the NW. The first two episodes of carbonate platform development show a slight increase in thickness westwards after a platform break due to synsedimentary faulting. A retrograding platform with an outcropping length of c. 100 m occurs above the first highstand unit. Carbonate systems showing stacking patterns and stratal terminations such as the ones studied herein are usually only observable on seismic data.

Theme 4. General topics in carbonate sedimentology

Special Session 4.3. Non-marine and marine carbonate factories and their expressions in sequence stratigraphy

Poster presentation

Sedimentary architecture of carbonate mud mounds: a case study on the Dengying Formation of Sinian in Sichuan Basin, China

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For carbonate mud mounds, research on the sedimentary architecture remains challenging. We add a study on single mound distribution and superimposed style, establish an evolution model and analyse the main factors affecting it. We used thin section, core and outcrop data to identify the architectural elements, describe the single mound distribution through the analysis of various wells. Based on outcrop, well and seismic analysis, we summarize the composite mound types and overlapping single-mound styles. We focus on the recognition of 6 to 4 levels of mud-mound architecture elements. The 6th to 4th grade architecture elements are composite mound, single mound and single micro-facies. The compound mounds are composed of 10 to 12 single mounds. High-amplitude composite mounds develop in the high energy zone, and have a width to height ratio of 1–3. The single mounds are vertically superimposed. Low-amplitude composite mounds develop in the transition zone; width to height ratio is 3 to 10. These single mounds are laterally superimposed. Laminal composite mounds develop in the low-energy zone; width-to-height ratio over 10. The lower Dengying Formation contains lateral accretion mounds as the upper part develops accretion or progradation mounds. Hence, the composite mound, single mound and single micro-facies act as the 6–4 levels of mud mound architecture elements. High-amplitude, low-amplitude and laminal composite mounds also occur. Lateral accretion mounds and aggradation mounds are present in the lower and upper part of the formation, which both are subjected to a continuous regression process, resulting in a gradual reduction in accommodation. The upper formation reflects an intermittent regression process in which accommodation remains almost unchanged.

Theme 4. General topics in carbonate sedimentology

Special Session 4.4. Resedimented carbonates – generation, transport, deposition

Oral presentation

Disintegration of isolated tropical carbonate platforms through flank collapse and canyon erosion

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Isolated tropical carbonate platforms in the Indian and Pacific oceans are currently in a stage of disintegration. Several factors control this condition, such as past sea-level fluctuations, ocean currents, and environmental conditions. Size reduction of the banks is a consequence of two processes: (1) Reduced carbonate production in the shallow part of the platforms resulting in minor sediment export to the platform slopes and the toe of slopes; platform edges thus do not prograde. (2) Slopes are dismantled through gravitational processes, as reflected by a series of distinct submarine geomorphological features. This study uses multibeam, seismic and seafloor observation data from the Saya de Malha Bank (Mascarene Plateau, Indian Ocean), the Maldives (Indian Ocean) and the Queensland Plateau (NE Australia, Coral Sea), to characterize the slope instabilities at the flanks of these carbonate buildups. Platform slope collapse in form of submarine rockfalls and landslides occurs along the edges of the banks and within middle and lower slope positions. The latter are volumetrically important having displaced several km^3 of sediment, for example at the flank of the Saya de Malha Bank (Mascarene Plateau, Indian Ocean). There, scarps are 300 m high and extend laterally for at least 40 km. The stepped shape of the scarps are interpreted to be a consequence of multiple episodes of slope destabilization — individual mass transport complexes bear volumes of 8 km^3 and more. Other slope segments of the platforms host submarine canyons several hundreds of m wide and 400 to 500 m deep. These canyons serve as routes for calciturbiditic export with the development of small turbidite lobes at the canyon exits. Here, we provide a catalogue of these submarine geomorphological features at the different locations analyzed. The windward and leeward exposure of the carbonate platform flanks which control sediment input to the slopes, together with the ocean currents that winnow and erode slope deposits, appear as most important controlling factors of slope dynamics.

Theme 4. General topics in carbonate sedimentology

Special Session 4.4. Resedimented carbonates – generation, transport, deposition

Oral presentation

A process sedimentology approach to understanding the deposition in fine-grained mixed siliciclastic–carbonate systems: a case study from the Altares Member within the Lower Triassic Montney Formation, Western Canada sedimentary basin

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Mixed siliciclastic–carbonate successions inherently possess high sedimentological heterogeneity as a result of dynamic depositional processes. Describing the complexity of texture, bedding and composition is commonly done to address microfacies within thin sections; however, upscaling these observations can be challenging depending on the scale of outcrop or subsurface drill core being studied. Within this study, we describe microfacies within a fine-grained mixed siliciclastic–carbonate interval (Altares Member) from the Lower Triassic Montney Formation within the subsurface of Western Canada to interpret depositional processes within mixed systems. The Altares Member consists of centimeter- to decimeter-scale bituminous siltstone and very fine-grained sandstone, interbedded with bioclastic packstone to grainstone beds that have been interpreted as being deposited in proximal offshore to offshore transition settings, with skeletal material transported by storm-generated currents from more proximal settings, possibly low-relief biostromes. However, detailed characterization of microfacies and depositional processes of the Altares Member in this study documents millimeter-scale grain size variability, distribution of skeletal material, sedimentary fabric, and sedimentologic heterogeneity. A complex mosaic of microfacies suggests that multiple processes deposited and reworked sediment including erosion and current reworking of the sea floor, suspension settling, bedload transport, and deposition from storm-generated flows. Microfacies are similar between carbonate-rich, mixed, and pure siliciclastic beds suggesting that similar sedimentary processes occurred throughout the deposition of sediment irrespective of the lithologies; however, the percentage of each microfacies varies stratigraphically, suggesting that dominant sedimentary processes fluctuated. Through this study, a better understanding of depositional processes associated with the short period of carbonate deposition of the Altares Member and its association with the surrounding siliciclastic-rich Montney Formation can help further refine depositional models in mixed siliciclastic–carbonate systems.

Theme 4. General topics in carbonate sedimentology

Special Session 4.4. Resedimented carbonates – generation, transport, deposition

Oral presentation

Resedimented carbonates in the evolution of the Dinaric Foreland Basin in northern Dalmatia, Croatia

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Resedimented carbonates constitute the bulk of the Dinaric Foreland Basin fill in northern Dalmatia, Croatia. The wedge-top basin comprises an array of asymmetrical sub-basins filled with the Promina Beds – a ~2000 m thick calciclastic succession of deep neritic to marginal-marine and alluvial deposits of middle Eocene to Oligocene age. These calciclastic sediments derive from redeposition of uplifted and eroded carbonates formed originally on the Adriatic Carbonate Platform during the Cretaceous, and intra-basinal carbonate ramps during the Eocene. Repetitive resedimentation phases involved carbonate debris of different age and grain size included in various transport and depositional mechanisms, resulting in diverse deposits over a relatively small area. The most conspicuous among these are mass-transport deposits (MTDs) that record subaqueous gravity processes in deep-marine and shallow-marine settings. Their features suggest that their transport direction was perpendicular to the southeast-trending structural lineaments. Most of them were triggered during the Bartonian and Priabonian, especially in the Korlat and Novigrad sub-basins which differ from others and from each other in resedimentation processes and host deposits. Specifically, the Korlat sub-basin is characterized by large limestone olistoliths and associated bipartite megabeds encased in deep neritic hyperpycnites. The origin of these blocks and gravity-flow deposits is attributed to major gravitational collapses of consolidated and unconsolidated sediments of Lutetian carbonate ramps, respectively. Contrarily, MTDs in the Novigrad sub-basin occur in offshore and offshore-transition strata and include calcilutite and calcarenite slumps, bioturbated conglomeratic slump-debrites with a “dough-like” appearance, and debrites deposited from debrisflows of variable competence. We suggest that these MTDs were triggered in fairly shallow water by a combined effect of strong earthquakes and sediment destabilisation due to pore water overpressure during forced regressions caused by sub-basin tectonic development. The results show that the integration of facies and microfacies analyses plays a crucial role in unraveling the intricate relationship between tectonics, sedimentation and relative sea-level changes.

Theme 4. General topics in carbonate sedimentology

Special Session 4.4. Resedimented carbonates – generation, transport, deposition

Oral presentation

Supercritical bedforms in Mississippian (Visean) carbonate slope clinothems and basin-floor sediment waves, Kentucky–Tennessee, USA

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The Lower–Middle Mississippian (Visean) Fort Payne Formation in Kentucky and Tennessee (USA) consists of two broadly defined depositional systems: (1) a 70 km wide belt of carbonate–shale clinothems that prograded southward into 150–200 m of water depth, and (2) a broad bottomset system of carbonate sediment waves. Sediment gravity flows, cascading density currents and thermohaline bottom currents were the dominant processes. A highly productive heterozoan carbonate factory produced crinoids, bryozoans, and brachiopods for both depositional systems. Siliciclastic mud was sourced from shelf delta/shoreface systems located far updip and along strike.

This study documents supercritical flow deposits in clinothem foresets and bottomset sediment waves. Clinothem foresets, which are inclined <1–8 degrees basinward, include channel-filling crinoid rudstones, hybrid event beds, interchannel shaley dolomitic mud, crinoidal shales, and toe-of-slope mass transport deposits. Some upper slope channels may be filled with crescentic bedforms of crinoid rudstone deposited as cyclic steps. There are also several basinward-thickening wedges of crinoid rudstone with backsets and antidune bedding, which may represent upslope-migrating cyclic steps. One of these wedges passes downdip into an 8 m-thick succession of climbing dunes (1 m-thick sets) made up of shaley crinoid rudstone, interpreted as a hydraulic-jump bar complex (MacDonald et al., 2013). It, too, passes downdip into another Tb unit and succeeding basinward-thickening wedge of backsets.

Bottomset sediment waves, which are present basinward of the clinothems, are among the first reported occurrences in the rock record. Wave lengths are 50–800 m and heights are 10–50 m. Some of the waves are oriented NE–SW and show evidence of migration to the SE. Antidunes and supercritical bedforms are present in the troughs, lower stoss, and lee slopes of sediment waves, and indicate paleoflows reached Fr>1 during acceleration down the lee slope, through the troughs, and decelerated to subcritical flow on the stoss slopes.

Theme 4. General topics in carbonate sedimentology

Special Session 4.4. Resedimented carbonates – generation, transport, deposition

Oral presentation

Carbonate turbidites of the Istrian flysch: composition and origin

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Stratigraphically, the Istrian peninsula (Western Croatia) consists of a thick succession of Mesozoic carbonate platform deposits and a middle Eocene foreland basin sedimentary sequence. The middle Eocene foreland basin sequence includes carbonate ramp deposits (so called Foraminiferal limestones) and the Istrian flysch, originated in the foredeep part of the basin. The Istrian flysch consists of hemipelagic marl and gravity-flow deposits. Gravity-flow deposits are carbonate debrites and high-density turbidites, and mixed siliciclastic–carbonate turbidites of a more distal character. The aim of this research is to determine the composition of carbonate turbidites and the source of carbonate constituents, and to find out which part of the underlying carbonates produced the bulk of the detritus. The composition was determined by the point-counting method on 42 samples. Based on the results, we can conclude that the detritus was predominantly redeposited from the contemporaneous Middle Eocene carbonate ramp. The carbonate ramp was located laterally within the same sedimentary basin and was the primary place of accumulation of biogenic detritus, which is mainly composed of ortophragminids, nummulitids and red algae. The lithoclasts, derived from older carbonate rocks, are represented to a lesser extent within the carbonate turbidites of the Istrian flysch.

Theme 4. General topics in carbonate sedimentology

Special Session 4.4. Resedimented carbonates – generation, transport, deposition

Oral presentation

Architecture and genesis of Miocene margin-collapse carbonates (Prebetic, Betic Cordillera, S Spain)

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A 475-m thick succession of resedimented carbonates crops out in the Castril area (Granada province, S Spain). These deposits reflect the collapse of a carbonate platform margin that took place in the Prebetic Zone during the late Serravallian–early Tortonian, a period of important tectonic uplift of the Betic Cordillera. Based on fieldwork mapping, stratigraphic logging, drone photogrammetry and macro- and microfacies analyses, we document the internal architecture of these deposits, examine their emplacement mode and explore the pre-conditioning factors and triggering mechanisms involved in the margin collapse. Three main redeposited units were identified. The lower unit is a 150-m thick calcareous megabreccia unconformably lying over Cretaceous marls. This is an heterometric, dominantly angular, clast-supported megabreccia with cobbles and boulders ranging from 10 cm to 5 m in diameter, locally up to 20 m. Clasts in the megabreccia include a mix of facies derived from truncated stratigraphic units from Cretaceous (?) to Miocene in age. The 10 to 25 m thick middle unit comprises bioclastic limestones filling up the irregular top surface of the lower unit. The middle unit includes 1) 5 to 20 cm thick bedded fine- to medium packstones laterally continuous over several hundreds of metres and 2) channelized medium packstones and fine-grained rudstones with basal cobbles and boulders arranged in bodies tens of metres wide and several metres thick. The upper unit is 250 to 300 m thick and includes marls intercalating channelized bodies of breccia and packstone beds. Skeletal grains are indicative of active carbonate production and shedding from the margin during deposition of the three units. Gravity transport and deposition of megabreccias during the main episode of margin collapse is interpreted as a submarine rock avalanche sourced from a steep, lithified carbonate platform margin. Subsequent deposition occurred in submarine slope aprons and channels sealed with hemipelagic sedimentation punctuated with sediment remobilization similar to previous events. A high-relief and lithified accretionary margin preconditioned the materials to fail due to fault movements and seismic shocks.

Theme 4. General topics in carbonate sedimentology

Special Session 4.4. Resedimented carbonates – generation, transport, deposition

Oral presentation

Shape-dependent settling velocity of skeletal carbonate grains: implications for calciturbidites

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Particle transport and deposition in turbidity currents is governed by the balance between turbulent suspension and gravitational settling, with settling velocity becoming dominant during the final rain-out phases of decelerated turbidity currents on lobes. For turbidites of carbonate composition, existing models do not fully incorporate the complexity of the hydrodynamics of irregular skeletal grains. Differential particle settling velocities play a role in the sorting of grains in turbidity currents. There is a preference of grains with higher settling velocities to be deposited first, yielding a settling-velocity gradient in vertical and longitudinal cross sections through turbidite beds. If sediments contain little variation in particle shape and density, such as typical for siliciclastics, then settling velocity is dominantly controlled by grain size. Carbonate sediments, in contrast, are composed of non-skeletal and skeletal grains, complete specimens and/or fragments, with various growth structures, producing a wide distribution of particle shapes. Similar-sized skeletal carbonate grains may therefore settle at very different rates, while particles of different size may settle together. This work aims to constrain the extent to which shape-dependent differential settling velocities influence sorting mechanisms in carbonate turbidity currents. Experiments using natural skeletal sand were conducted to investigate the settling of carbonate grains in (i) isolation, (ii) vertically-settling suspensions, and (iii) turbidity currents. Size, density and shape parameters were analysed using high-resolution micro-CT. It was found that the effect of particle shape on the sorting mechanism operating in carbonate sediment suspensions becomes increasingly significant as grain size increases, in particular above medium sand. Carbonate turbidites may therefore be more poorly sorted than siliciclastic turbidites, which is expected to result in lower primary porosity in calciturbidites compared to siliciclastic turbidites.

Theme 4. General topics in carbonate sedimentology

Special Session 4.4. Resedimented carbonates – generation, transport, deposition

Poster presentation

Tortonian carbonate intercalations in the foreland hemipelagic marls of Latium–Abruzzi (Central Italy). Depositional processes, triggering mechanisms and sediment composition of carbonate gravity flow

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A key setting where carbonate platforms can be investigated is a foreland basin, where shallow-water sedimentation may develop in different conditions and positions. In the distal edge of peripheral foreland basins, shallow-water carbonates often develop and form the lower unit of the underfilled trinity of Sinclair. According to this author, peripheral foreland basins include three stratigraphic units which are commonly superimposed during the basin migration. These units, known as the “underfilled trinity”, consist of: i) a basal unit corresponding to carbonate deposition on the distant foreland basin; ii) a middle unit represented by hemipelagic mud sedimentation offshore; and iii) an upper unit formed by deep-water, turbiditic–siliciclastic sedimentation which develops toward the orogenic margin of the basin. In the central Apennines (Latium–Abruzzi, Central Italy) the first member of the underfilled trinity is represented by a basal Burdigalian to Serravallian Miocene carbonate ramp, the Lithothamnion and Bryozoan Limestones, which lie on a Paleogene unconformity. The carbonate ramp is overlain by Tortonian hemipelagic marls represented by the Orbulina Marls, followed by turbiditic, siliciclastic succession deposited in the foredeep system. This work focuses on the bioclastic intercalations occurring in the Orbulina marls. The calcareous nannofossil assemblages at the base of the intercalation indicate a Tortonian age, attributable to Biozone MNN9. The compositional features and sedimentary structures of carbonate intercalation indicate deposition from gravity flows (turbidity currents) sourced by areas of active carbonate factory placed in the oligophotic zone. In this work, we analyse the role of climate conditions characterizing the Central Mediterranean area, as well as the oceanographic conditions which promoted the gravity flows on the Tortonian Latium–Abruzzi carbonate ramp.

Theme 4. General topics in carbonate sedimentology

Special Session 4.4. Resedimented carbonates – generation, transport, deposition

Poster presentation

Calci-turbidites reveal seismic cycles of transform faults on slow-spreading mid-ocean ridge since 100 kyr BP

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In addition to subduction zones, spreading zones also generate damaging earthquakes on Earth. A series of large-magnitude earthquakes occur periodically due to cyclic activities of the oceanic transform faults in the spreading zones. The earthquake recurrence pattern is critical in understanding the dynamics of transform faults and assessing seismic hazards. However, due to the paucity of high-resolution earthquake records spanning hundreds of kyrs, it is difficult to reconstruct seismic cycles in geological history only using fragmented data from modern seismic observation. In the study, we target one gravity core located in the transform fault zone of Central Indian Ridge. We analyze the grain size end member, X-radiographs, and major elements of sediment in the core. Ten calci-turbides with typical normal grading have been recognized in the core. They are characterized by planar lamination and current-ripple cross-lamination and are rich in planktonic foraminifera. Based on the low sediment accumulation rate (9–13 cm/kyr) inferred from carbon-14 and curves of oxygen isotopes, we suggest that the calci-turbidites are seismo-turbidites rather than caused by submarine failures. The turbidite records that span 100 kyr reveal that the seismic cycles of Central Indian Ridge are 2.6 kyr and 14 kyr. This study shows that long-term earthquake records are essential to capture the less frequent but most dangerous events.

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Theme 4. General topics in carbonate sedimentology

Special Session 4.4. Resedimented carbonates – generation, transport, deposition

Poster presentation

Erosive channels in deep-water areas surrounding carbonate banks of the Queensland Plateau (NE Australia)

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It is proposed that sediment transport in deep-water areas surrounding the carbonate banks of the Queensland Plateau, Coral Sea, is channelized by erosive channels. These channels are up to 200 km long, extending from depths of about 500 m towards the outer continental slope. The study area comprises a 40 km wide passage between the carbonate banks of Magdelaine Cays and Willis Islets, with depths ranging from 500 m to more than 1000 m. The seafloor morphology in the passage appears to be controlled by mass-transport complexes originating from the flanks of the banks and by drift sediments. A prominent morphological element of the passage is a slightly bended channel, up to several kilometres wide and several tens of meters deep. The main channel course emerges from a flat area of seafloor at depths of about 500 m. The channel runs parallel to the bank edges, following the bathymetric gradient, and numerous small tributaries flow in from the sides. The bottom of the channel is grooved by up to 8 m deep furrows that are oriented parallel to the channel axis. Multibeam swath echosounder and Parasound (parametric sediment echosounder) data show that the channel cuts into underlying drift deposits. Along the channel course there are several morphological steps, caused by outcropping hard beds and a depression is present at the toe of one of these submarine cliffs, sharing the morphological characteristics of a plunge pool. Sharp erosional edges and the lack of sediment coverage point to ongoing sediment transport within the channel. This view is further supported by high-resolution video data from the seafloor, which show current ripples on the channel floor. Parasound data reveal the existence of buried channels, likely representing precursor erosive stages. Comparable channels are therefore seen to represent an important element of the deep-water sediment transport system surrounding the carbonate banks of the Queensland Plateau.

Theme 4. General topics in carbonate sedimentology

Special Session 4.4. Resedimented carbonates – generation, transport, deposition

Poster presentation

Eocene base-of-slope resedimented carbonate deposits of the Gargano Promontory (Italy)

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The variety and complexity of depositional processes which acted to generate base-of-slope resedimented gravity flow carbonates, often make their distribution and architecture difficult to reconstruct and predict. To determine whether normal sediment exportation processes, slope destabilization or tectonic-induced re-sedimentation processes are the triggering mechanism for gravity flow development, a detailed analysis of carbonate sediment composition, in terms of facies, spatial distribution and depositional architecture of these deposits, is needed. The Apulia Carbonate Platform (ACP) represents one of the most extensive Mesozoic–Cenozoic isolated carbonate domains of the Tethyan Ocean. During the Eocene the ACP experienced a general uplift and subaerial exposure to which are related regional unconformity, gravitational collapses and massive deposition of slope and base-of-slope resedimented carbonates that are spectacularly exposed in the Gargano Promontory. In this setting, a basal mega-breccia (Grottone Megabreccia) and breccias with bioclastic turbidites (Peschici Formation), alternating with micritic limestones and pelagic marlstone, represented the basinward exportation of loose sediments that belonged to the Cretaceous and Eocene margins. Thus, in order to characterize the facies and the spatial distribution of these deposits, a detailed lithofacies map of well-exposed outcrops in the whole area was performed. Previous studies of these systems, still leave many open questions about what may have been the controlling factors that affected the depositional architecture and the transport mechanisms. These still open questions can find answers in detailed facies distribution studies which can improve the scientific knowledge about these systems and can help in the exploration of subsurface analogues in terms of identification and characterization of carbonate reservoirs, since submarine fans or aprons represent important oil and gas reservoirs around the World.

Theme 4. General topics in carbonate sedimentology

Special Session 4.4. Resedimented carbonates – generation, transport, deposition

Poster presentation

The white cliffs of Aktau: bioclastic deposits of the Maeotian (Upper Miocene, Eastern Paratethys) of western Kazakhstan

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Aktau, the coastal city on the Caspian Riviera (Kazakhstan), owes its name to light colored, up to 15 m high coastal cliffs. Undeformed strata allow for observing lateral facies changes along a ~1.5 km long section. The deposits are likely of Maeotian age, commonly comprised of shelly and oollitic limestones and marlstones in the eastern Paratethys. A preliminary interpretation of paleodepositional environments is presented. Data were acquired through detailed logging and mapping. Facies analysis indicates three distinct vertically stacked sedimentary packages: Units 1–3. Units 1 and 2 unconformably rest on m-scale microbial carbonate mounds. Unit 1: Exposure <1.7 m, comprised of dm-scale interbeds of grey, pinkish, greenish, and beige mudstones and grainstones. There are no visible sedimentary structures except for a weakly bioturbated layer (BI 0-2). Unit 1 is likely a diagenetically modified shoreface deposit. Unit 2: Exposure <5 m thick, light colored grainstones comprised of large-scale cross beds with up to 34° dipping foresets. Exposed bottomsets are abundant in climbing ripples. Unit 2 is interpreted as amalgamated coastal deposits including shoreface, lagoonal, and aeolian deposits. A narrow inlet is perhaps characterized by supercritical currents. Unit 3: Exposure <9 m thick, showing light colored grainstones containing dm-scale low-angle cross- and plane-parallel beds. Interbedded cm/dm-scale wave ripples and rare, small green mudstone lenses are present, as well as a 0.2 m thick pebbly event bed. Unit 3 originated in alternating beach and upper shoreface environments, transitioning upward to a middle shoreface witnessing a major storm or tsunami. Base-level fall at the base of Unit 2 was followed by a transgression and progressive deepening of the system. Bioclastic abundance suggests significant biogenic productivity and deficit of the terrigenous input. Intense reworking by a range of currents is responsible for variable grain-size distribution. This case study shows sedimentological evidence of Maeotian shoreline dynamics in a part of the Paratethys starved of siliciclastic sediment. We have demonstrated the importance of sediment transport mechanisms and depositional environments, hoping to inspire future process sedimentology studies in bioclastic systems.

Theme 4. General topics in carbonate sedimentology

Special Session 4.4. Resedimented carbonates – generation, transport, deposition

Poster presentation

Lateral facies variability in carbonate turbidites in Ionian Basin outcrops (Cretaceous, Albania)

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Carbonate slope deposits form an important part of modern carbonate platform-slope-basin systems and ancient counterparts. Carbonate sediment sourced from platform margins, and remobilisation of the slope itself, may accumulate in slope aprons or submarine fans, depending on the system morphology and the nature of the carbonate factories involved. This work investigates the deposits of unconfined carbonate sediment gravity flows derived from the margins of the southern province of the rudist-dominated Cretaceous Apulian carbonate platform. The studied deposits are part of the Ionian Basin succession that crops out today over ca. 25 km along strike, in a fold-and-thrust belt in southern Albania. The basal part of the succession (130 m, Campanian) comprises undeformed, sheet-like calciturbidites. This package is abruptly overlain by a series of five 10–50 meters thick mass transport deposits (MTDs) and intercalated calciturbidites (>200 m, Maastrichtian–Paleocene) that restore the MTD-inherited topography. Here, we focus on a 50 meter thick interval of the undeformed turbidite package, which is composed dominantly of grainy and muddy calciturbidites and occasional calcidebrites and hybrid beds. Bed thickness ranges from a few centimeters to over three meters. Grains are principally of bioclastic origin and dominated by rudist fragments, but coarser grains include carbonate intraclasts. Deformed mud clasts are common; usually 'floating' in a muddy matrix. Thin-section analysis facilitated the occasionally problematic discrimination between muddy turbidites and hemipelagic deposits rich in planktonic foraminifers. Three sedimentological logs of the same interval are presented at very high-resolution (sub-cm-scale) from three localities with several kilometers along-strike spacing from each other. Three marker beds are used for correlation between localities. The distribution of process-based facies is discussed using statistical methods to provide insight into the variation and predictability away from one-dimensional observations as for example encountered in exploration wells.

Theme 4. General topics in carbonate sedimentology

Special Session 4.4. Resedimented carbonates – generation, transport, deposition

Poster presentation

Early Cretaceous to Eocene calciturbidites and calcidebrites of the Ionian Zone, western Greece: implications for the role of salt tectonics processes

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Submarine gravity flow processes on carbonate platform slopes favor the deposition of calciturbidites and calcidebrites on the adjacent deep-water basins. The scope of the present study was to identify this type of gravity flow deposits in Lower Cretaceous–Eocene carbonate sequences of the Ionian Zone in western Greece and to evaluate the role of salt tectonics in the depositional pattern. In several locations across the Ionian Zone carbonate sequences, detailed lithostratigraphic analysis was performed. In order to estimate the geometrical properties of the calciturbiditic and calcidebritic intervals remote sensing methods were applied including high-resolution aerial imaging, satellite images, and digital elevation models. In the identified intervals thin sections were examined for textural analysis. In the measured sections monotonous mudstone calcareous facies are intercalated with distinct, thick-bedded carbonate layers characterized as packstones, grainstones, and floatstones. Fragmented fossils and rounded to subrounded chert and limestone clasts, floating in a calcareous matrix, suggest deposition by debrites. Graded beds which gradually pass to planar and ripple cross-laminated tops, indicate the vertical and lateral transformation of debris flows to turbidity currents. Calcidebrite/calciturbidite compositional variations have been recognized across the study area. Debritic facies are more common adjacent to salt exposures while distally turbiditic facies prevail. Small-scale syn-sedimentary folds accompanied with chert bodies of irregular shape suggest sediment instability at a primary depositional stage. This type of deformation is more intense close to the salt diapir The lateral extent of calcidebrites – calciturbidites is estimated to reach up to 3–4 km. Internal low-angle unconformities are also indicative of the control of salt uprise in the depositional process. Microscopic analysis verified the textural profile of gravity flow deposits. Distinct calcidebritic and calciturbiditc intervals have been recognized in the Early Cretaceous to Eocene carbonate succession. The textural and geometrical properties indicate a carbonate slope setting controlled by salt tectonics.

Theme 4. General topics in carbonate sedimentology

Special Session 4.5. Modern advancements in the characterization of dolomite

Keynote lecture

Tracking trace element concentrations in dolomite during high-temperature experiments

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Measured trace element (TE) concentrations in dolomite are commonly used to constrain the chemistry of the dolomitizing fluids. Our confidence in such interpretations is limited by a lack of experimental data. Here, laboratory experiments were employed to examine TE incorporation in dolomite. In the experiments, aragonite ooids were dolomitized Mg–Ca–Cl–Na solutions at 215°C. To evaluate the degree to which TE concentrations reflect fluid concentrations, [Na] was tracked in the solids throughout the dolomitization reaction. To investigate the degree to which TE concentrations reflect those of the Sr-containing precursor, [Sr] was also tracked. Mineralogy of the solids was determined using powder XRD, and TE concentrations were measured using ICP-MS. The key observations are: (i) [Sr] rapidly decreases from ca. 6000 ppm in the aragonite reactant to <1000 ppm during replacement by dolomite and continues to decrease to <100 ppm during recrystallization as dolomite stoichiometry and cation ordering increase; (ii) [Na] strongly correlates with [NaCl] in the dolomitizing fluids, such that low [Na] fluids yield ordered dolomites with [Na] = <10 ppm, and high [NaCl] fluids yield ordered dolomites with [Na] = ca. 3000 ppm; (iii) higher fluid [NaCl] correlates with slightly higher [Sr] in the dolomite, but the dominant trend is decreasing [Sr] during dolomitization. The experimental results provide a number of key insights. First, the data are consistent with the assumption that [Sr] tends to be lower in more stoichiometric dolomites, but suggest that the relationship may be driven by recrystallization. Second, the data show that under fluid-buffered conditions, such as those employed in the experiments, dolomite inherits very little Sr from the aragonite precursor, and thus dolomite [Sr] may more likely reflect [Sr] in the dolomitizing fluids. Third, the strong correlation between fluid [Na] and dolomite [Na] suggests that [Na] in dolomite may provide valuable constraints on the nature of the dolomitizing fluids, and is a potentially valuable directional indicator for spatial and temporal changes in fluid chemistry.

Theme 4. General topics in carbonate sedimentology

Special Session 4.5. Modern advancements in the characterization of dolomite

Oral presentation

Genesis of island dolostones during rapid island subsidence: example from the Xisha islands, South China Sea

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Miocene carbonate successions found on many isolated oceanic islands throughout southeast Asia commonly include unconformity capped "island dolostones" units. On Shidao, located in the Xisha Islands in the South China Sea, well XK-1 (1268.2 m deep) penetrated a thick succession of carbonates before being terminated in the Jurassic metamorphic basement. The lower part of the succession is composed of the Sanya Formation (Early Miocene) and the overlying Meishan Formation (Middle Miocene), ~700 m thick, that are formed of limestones and dolostones. An unconformity divides the Sanya Formation into a Lower Member formed largely of limestones, and an Upper Member formed of dolostones (DI-8). DI-8 is separated by a major unconformity into lower (DI-8L) and upper (DI-8U) units, that both include numerous subaerial unconformities. The overlying Meishan Formation is a limestone succession that includes three unconformity-capped dolostones intervals (DI-5, DI-6, DI-7). Strata below the numerous exposure surfaces throughout the Sanya Formation and Meishan Formation are highlighted by Fe-staining, biomoulds, cavities, caves, and solution breccia development. The weakly fabric-retentive dolostones in DI-5 to DI-8 are formed of dolomite crystals that have a dirty core encased by a clear rim, with $\delta^{18}O$ values of +0.3 to +4.7‰ (average +2.0‰, n = 50), $\delta^{13}C$ values of +2.2 to +3.2‰ (average +2.5‰, n = 50), Fe concentrations of 44–442 ppm (average 149 ppm, n = 50), Mn concentrations of 5–197 ppm (average 27 ppm, n = 50), Sr concentrations of 169–257 ppm (average 218 ppm, n = 50), and $^{87}Sr/^{86}Sr$ values of 0.70847–0.70900 (average 0.70879, n = 32). In all cases, dolomitization postdated the subaerial exposure. The $^{87}Sr/^{86}Sr$ values suggest that the dolostones in DI-8L formed during the late Early Miocene, whereas the dolostones in DI-8U, DI-7, DI-6, and DI-5 probably formed simultaneously during the Late Miocene even though these units are stratigraphically hundreds of meters apart and were located well below sea level. Dolomitization was preferentially focused in those strata with high porosities and permeabilities that allowed easy circulation of the seawater through the rock. This model suggests that dolomitization was not restricted to strata that were at or close to sea level.

Theme 4. General topics in carbonate sedimentology

Special Session 4.5. Modern advancements in the characterization of dolomite

Oral presentation

The effect of Ca-Mg-carbonate mineral phase on oxygen isotope fractionation in experimental dolomites

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Sedimentary dolomites are abundant in the rock record, potentially archiving the oxygen isotope composition of the environments in which they formed. Presently, use of dolomite oxygen isotope values as a resource for studying paleoclimate is limited by large uncertainties in published oxygen water–mineral fractionation values.

Laboratory experiments show that dolomitization occurs through a series of dissolution/precipitation reactions, whereby a $CaCO_3$ mineral is replaced by a succession of Ca-Mg-CO_3 minerals, starting with disordered very high-Mg calcite and ending with stoichiometric, ordered dolomite. Published oxygen isotope water–mineral fractionation factors for dolomite do not discriminate between the various Ca-Mg-CO_3 phases. We hypothesize that the discrepancies in published water–mineral fractionation values may be attributed to quantifiable differences in fractionation between various Ca-Mg-CO_3 phases.

To test this hypothesis, well-controlled, high temperature dolomitization experiments were used to track $\delta^{18}O_{carb}$ and Δ_{47} clumped isotope composition of the various Ca-Mg-CO_3 mineral phases. Calcite and aragonite were dolomitized in Mg-rich fluids at 150°C, 190°C, 200°C, and 250°C, and products were characterized using powder X-ray diffraction (XRD), then analyzed for $\delta^{18}O_{carb}$ and Δ_{47} clumped isotope composition.

Consistent with previous studies, we observe that dolomitization of calcite and aragonite proceeds through a series of increasingly stable Ca-Mg-CO_3 phases: very high-Mg calcite (i.e., protodolomite), poorly ordered dolomite, and well-ordered dolomite. Formation temperatures from Δ_{47} clumped isotope analyses are generally consistent with experimental temperatures in pure mineral phases, however, temperatures in mixed phase samples are less accurate. Experimental results show a clear relationship between $\delta^{18}O_{carb}$ and Ca-Mg-CO_3 cation ordering, which is interpreted to reflect differences in water–mineral fractionation in the various Ca-Mg-CO_3 mineral phases that are historically called dolomite.

Theme 4. General topics in carbonate sedimentology

Special Session 4.5. Modern advancements in the characterization of dolomite

Oral presentation

Towards an improved understanding of palaeothermometry data in dolomites

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Dolomitic rock (dolostone) is a major topic in carbonate research and a complex archive of its palaeoenvironment and diagenetic pathways. Two of the arguably most common proxies to assess post-depositional (burial) temperatures include carbonate clumped-isotopes and fluid-inclusions. In some cases, the temperature data obtained provide overlap, more often clumped-isotope and fluid-inclusion temperatures differ significantly. This has led to controversy in the scientific community regarding the applicability and accuracy of these palaeothermometers. Here, we present a case example from the Triassic Latemar isolated platform in the Dolomite Mountains of Northern Italy. We applied both thermometers and made use of a detailed petrographic, paragenetic, and geochemical dataset. Independent of the spatial position at Latemar, Δ_{47} clumped-isotope (46–97 °C) and fluid-inclusion data (44–292 °C) provide contrasting palaeotemperature estimates for dolomitizing fluids. An apparent lack of systematic patterns in fluid-inclusion data (homogenization temperature, salinity, density) results from analyses of micrometer-sized growth zones within a single crystal. The composition of the individual fluid inclusions represents a `snapshot´ of fluid mixing with variable endmember elemental ratios. The presence of three fluid types (crystalline basement brine, halite-dissolution brine, modified seawater) in all carbonates suggests that all fluids coexisted during contact metamorphism and coeval dolomitization of Latemar carbonates. Non-equilibrium processes overruled thermodynamic controls on the precipitation of diagenetic phases. Fluid mixing resulted in the precipitation of two complex carbonate successions. The Δ_{47} dolomite data represent bulk temperatures, averaging the mixing ratio of fluids with different temperatures and their respective volume. The choice of the palaeothermometers depends on the research question posed, a combined application of both approaches is recommended.

Theme 4. General topics in carbonate sedimentology

Special Session 4.5. Modern advancements in the characterization of dolomite

Oral presentation

Rare earth elements in cap dolostones: implications for ocean redox conditions in the aftermath of the Marinoan glaciation

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The syn-deglacial cap dolostones record the marine redox conditions and chemistry in the immediate aftermath of the Marinoan glaciation. Cap dolostones of the Ediacaran Doushantuo Formation on a shelf-to-basin transition on the Yangtze platform in south China were analyzed for rare earth elements (REE) and yttrium concentrations. The shale-normalized REE and Y patterns (REYSN) show significant fractionations that are characterized by light REE depletion, slight middle REE enrichment, positive Eu anomalies, and slightly super-chondritic Y/Ho ratios. There are no statistically significant shale-normalized negative Ce anomalies in the REYSN of the dolostones. The REYSN patterns reveal the extensive ocean anoxia during the early Ediacaran. The Doushantuo cap dolostones from the inner shelf exhibit distinct REYSN patterns compared to those from the shelf edge and slope, which are uniformly less fractionated with suppressed light REE depletion and MREE enrichment, and no Eu anomalies. The spatial variations in the REYSN patterns suggest that meltwater probably affected the seawater chemistry within the restricted inner shelf during the glaciation–interglaciation transition. The cap dolostones from the shelf edge show REYSN patterns with almost identical stratigraphic trends in two sections that are twenty-one km apart. The stratigraphical decrease in the (Ce/Ce*)SN together with the increase in the Y anomaly and decrease in the middle REE anomaly, implies a possibly progressive increase of dissolved oxygen in the surface ocean in the immediate aftermath of the snowball Earth.

Theme 4. General topics in carbonate sedimentology

Special Session 4.5. Modern advancements in the characterization of dolomite

Poster presentation

Understanding magnesium-rich carbonates with warped crystal lattices: an experimental approach

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Dolomite and related Mg/Ca carbonates are common rock-forming minerals (dolostones). Dolomites crystallise in the space group R-3 with trigonal symmetry and typically display a rhombohedral growth habit. A specific subtype of dolomite is saddle dolomite (a.k.a., baroque dolomite, etc.), characterised by curved (warped) lattices. Saddle dolomite shows sweeping extinction under cross-polarised light, which points to lattice strain. Saddle dolomites are considered one of the key indicators of warm-to-hot hydrothermal fluids in the burial diagenetic realm. They co-occur with Mg/Ca carbonates that often (but not always) lack warped crystal surfaces, and, hence, the physicochemical conditions that lead to their formation remain unclear. Here, we present data from an experimental study aiming to systematically explore the formation of saddle dolomite as a function of various experimental parameters (temperature, crystal size of reactants, fluid salinity and Mg/Ca ratio of solutions). Experimentally precipitated dolomites that grow epitaxially on rhombohedral or saddle dolomite seeds exhibit warped surfaces, whereas Mg-rich calcite crystals that grow on calcite seeds form flat surfaces. High Mg-calcite that precipitates at high temperatures (~ 220 °C) from calcium-rich fluids (Mg/Ca = 0.43) equally displays curved surfaces. In all cases, however, crystals with curved surfaces are characterised by excess calcium (Mg/Ca ~ 0.31–0.35). These results suggest that the curvature of crystal surfaces is basically related to excess Ca in the crystal structure causing lattice strain. Based on the data shown here, dolomite precursor surfaces (substratum effect) on which the crystals can grow, diagenetic environments that provide excess Ca (e.g., brines) and rapid growth kinetics at high temperatures seem to facilitate the formation of crystals with warped lattices.

Theme 4. General topics in carbonate sedimentology

Special Session 4.6. Carbonate sedimentary systems and their petrophysical expression

Oral presentation

Multi-scale geological significance of acoustic properties in carbonates

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For the subsurface characterization of carbonates, linking physical properties with their geological significance is of primary importance. To address this issue, we investigate reservoir-scale sedimentary sections on Samos Island, combining geological characterization and multi-scale acoustic measurements. We describe sedimentary facies at outcrop and acquire P-wave velocity measurements at three scales: i) reservoir-scale using seismic refraction acquisition; ii) log-scale, acquiring in-situ acoustic measurements on the outcrop surfaces; and iii) plug-scale as usually done in the laboratory with ultrasonic measurements. We define relationships between acoustic velocity and microstructure at a millimetre-scale Representative Elementary Volume (REV1) based on laboratory measurements and thin-section petrography. At the outcrop scale, we link in-situ P-wave velocity variability with sedimentary facies while characterizing centimetre-scale REV2. We also quantify acoustic properties at the reservoir scale and related them to a meter-scale REV3.

Using ultrasonic P-wave velocity measurements and plug densities, we construct 1-D synthetic seismograms showing meter-scale seismic reflectors equivalent to crosswell seismic frequency range. We show that: i) high-amplitude reflectors usually fit with facies changes associated with diagenetic contrasts; ii) reflection free-zones match with a succession of facies changes affected by diagenetic homogenization. Consequently, the spatial diagenetic overprint can firmly control high-resolution seismic reflectors in non-marine carbonates. Nevertheless, this conclusion is suitable only if small-scale acoustic properties acquired at REVs 1 and 2 are invariant with upscaling to REV 3, a rarely valid hypothesis for heterogeneous geological objects. Indeed, at least for the characterized study sites, P-wave velocity decreases from the laboratory to the reservoir scale due to the nesting of multi-scale geological heterogeneities. Therefore, in case of low burial conditions, the microscale matrix porosity control of ultrasonic P-wave velocity may be progressively lost with upscaling due to the addition of larger heterogeneities corresponding to crack and fracture porosity.

Theme 4. General topics in carbonate sedimentology

Special Session 4.6. Carbonate sedimentary systems and their petrophysical expression

Oral presentation

Towards an integrated approach to characterize pore connectivity in marine to continental rift carbonates (Danakil Depression, Ethiopia)

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Continental rift carbonates are characterized by heterogenous sediment composition rendering the interpretation of petrophysical properties difficult. An analogue suite of Pleistocene and Holocene carbonate facies from the Danakil Depression (Ethiopia), recording the cyclic transition from marine-to-hypersaline-to-continental conditions, has been studied for sediment composition (petrography), petrophysics (porosity and permeability) and 3-dimensional pore architecture (multi-scaled X-ray CT scanning). Thirty-one cylindrical plugs encompassing the following facies: (i) oolitic grainstone, (ii) scleractinian-coral framework, (iii) hot spring and lacustrine carbonate, (iv) bivalve-rich marine grainstone, (v) microbialite and (vi) red-algae framework, were analysed. Based on segmented 3D CT datasets, an integrative pore network modelling approach was used to visualize connectivity (pore throats and channels) and quantify tortuosity, coordination number and channel length. Quantified parameters were checked against sedimentary facies and fabrics, as well as diagenetic overprint. This evidences clear relations between the studied facies and quantified pore network parameters. Pore network models were found to be a valuable tool for understanding and characterizing meso-to-macro-scale petrophysical heterogeneity in carbonate facies. It is proposed that aforementioned parameters are used collectively when quantifying pore networks of complex carbonates. Moreover, pore network models can be used for simulating a variety of different physical and chemical processes in porous carbonate facies, respecting the carbonate fabric and texture.

Theme 4. General topics in carbonate sedimentology

Special Session 4.6. Carbonate sedimentary systems and their petrophysical expression

Oral presentation

Uniform petrophysical properties of carbonate contourite drifts

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Delta drifts are carbonate contourite drifts that form when sediment laden current flows through channel openings into a deeper basin where the currents release their sediment load to form a submarine delta-shaped body. These delta drifts consist mainly of well sorted skeletal debris from shallow-water areas near the channels, the fauna living in such channels, and pelagic components. Their petrophysical properties display little variations of velocity and resistivity at any given porosity. The narrow property ranges contrast with platform carbonates typically displaying a wide scatter.

The studied delta drifts are the Miocene drift in the Kardiva Channel in the Maldives (cored during IODP Expedition 359) and the Upper Cretaceous (Campanian–Maastrichtian) delta drift in the bioclastic wedge of the Orfento Formation in the Maiella, Italy. Maldives' core plugs are dominated by weakly cemented, wackestones to packstones at the base that coarsen upwards to skeletal-rich grainstones to rudstones. Maiella plug samples are well-cemented grainstones to rudstones. We measured porosity and grain density using a helium pycnometer, acoustic velocity and electrical resistivity using a New England Research Autolab1000.

Porosity ranges from 4–41% (Maiella) and from 15–59% (Maldives). Permeability is high (0.2–1280 mD), and in contrast to the Maldives, Maiella samples correlates well to porosity. Acoustic velocity ranges from 2.1–4.9 km/s in the Maldive samples, while they range between 3.2–5.9 km/s in the Maiella samples. Velocity–porosity data closely align with Wyllie's time average trend, indicating that despite large variations both datasets are dominated by similar pore geometries.

Likewise, resistivity measurements display a narrow range of the formation factor m (1.8–2.9). In comparison, platform carbonates typically have a large range of m, and travertine, tufa, and reefal limestones show even larger ranges. Mudstones of the Vaca Muerta Fm exhibit low values of m and are comparable to carbonate contourite samples.

The narrow range of acoustic and resistivity values of these laboratory measurements are in concert with the log signatures measured in the sites of IODP Exp 359 in the Maldives, indicating that the uniform petrophysical properties is a characteristic of carbonate contourite drifts.

Theme 4. General topics in carbonate sedimentology

Special Session 4.6. Carbonate sedimentary systems and their petrophysical expression

Poster presentation

Sedimentology and geochemistry of carbonate-bearing argillites on the southeastern flank of Mount Cameroon (Likomba)

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Sedimentological, geochemical and petrographic studies were carried out on carbonate-bearing argillites outcropping at the southeastern flank of Mount Cameroon (Likomba) to determine the lithofacies and their associations, major element geochemistry and mineralogy.

Major elements of the rocks were analyzed using XRF technique. Thermal analysis and thin section studies were carried out accompanied with the determination of insoluble components of the carbonates.

The carbonates are classified as biomicrites with siderite being the major carbonate mineral. Clay, quartz and pyrite constitute the major insoluble components of these rocks. Geochemical results depict a broad variation in their concentrations with silica and iron showing the highest concentrations and sodium and manganese with the least concentrations. Two factors were revealed with the following elemental associations, Fe_2O_3–MgO–Mn_2O_3 (72.56%) and TiO_2–SiO_2–Al_2O_3–K_2O (23.20%) indicating both Fe-enrichment, the subsequent formation of the siderite and the contribution of the sediments to the formation of these rocks.

The rocks consist of cyclic iron-rich carbonates alternating with sideritic-shales and might have been formed as a result of variations in the sea conditions as well as variation in sediment influx resulting from transgression and regression sequences occurring in a shallow to slightly deep marine environments. The rocks lie unconformably beneath the CVL and are highly fractured due to the overburden of the overlying igneous rocks.

Theme 4. General topics in carbonate sedimentology

Special Session 4.6. Carbonate sedimentary systems and their petrophysical expression

Poster presentation

Zechstein petrophysical facies variability across the greater Mid North Sea High area

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The Zechstein Supergroup is a succession of carbonates and evaporites that form an important component in many North Sea petroleum plays, providing trapping structures, seals, and reservoirs. Many locations across Europe also utilise the Zechstein for geological storage. Extension and thermal subsidence in the early Permian developed the Northern and Southern Permian Basins which are partitioned by the W–E striking Mid North Sea High (MNSH). In the latest Permian, the basins connected to the world ocean causing the formation of the Zechstein Sea. Repeated flooding and evaporation events resulted in the generation of up to five major cycles (Z1–Z5). Previous seismic-based studies mapped a N–S orientated seaway through the MNSH that allowed for communication between the basins; however, the timing of this connection remains poorly understood. Using the available legacy well data, this work defines the petrophysical characteristics for all formations and cycles within the Zechstein and then constructs regional well correlation panels to understand the changes in facies distribution across the MNSH. The seaway through the MNSH exerted significant control on facies distribution, and the new well correlation shows that the seaway first closed in late Hauptdolomit (Z2) times. This isolation of the Southern Permian Basin led to significant accumulations of Z2 Halite along the southern margin of the MNSH, whereas this facies remains elusive along the northern margin. Conversely, the Z3 Halite is abundant within all palaeo-lows across the greater MNSH area. The Zechstein Supergroup shows thinning on carbonate platforms and towards the Central Graben; however, as the upper Zechstein cycles often remain complete, this suggests that the thinning was controlled by deposition rather than erosion as previously thought. Our results indicate significant Zechstein facies variability and the need for a greater regional understanding, especially as recent discoveries have established the MNSH as the frontier of North Sea hydrocarbon exploration with potential for subsurface storage. This work will provide learnings on the differences between the Northern and Southern Permian Basins, with implications not only for understanding petroleum reservoir distribution but also for the screening of halite storage sites.

Theme 4. General topics in carbonate sedimentology

General Session

Oral presentation

Diagenetic evolution of the Middle Eocene ramp carbonates in the Bombay offshore basin, India

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The Bassein Limestone of the Bombay offshore basin offers an analog for revealing the diagenetic evolution of the Eocene ramp carbonates. An integration of mesoscopic core study with the microscopic petrography and geochemical data reveals that an array of diagenetic processes through the eogenetic, mesogenetic, and telogenetic episodes influenced these carbonates under four diagenetic realms, viz., marine-phreatic, meteoric-phreatic, burial, and uplift. The sequential paragenetic commences with eogenesis in the marine-phreatic and meteoric-phreatic diagenetic environments. The marine-phreatic diagenetic signature comprises of dominant micritization, moderate framboidal pyritization, marine cementation (syntaxial overgrowth of rim cements), genesis of matrix-replacive fine-crystalline dolomites, and early stages of mechanical compaction (e.g., grain rearrangement and contortion, fracturing, and deformation of micritized grains) before significant burial takes place. The meteoric-phreatic diagenetic environment incorporates dissolution of the bioclasts and metastable micritic matrix, neomorphic alteration of the lime mud matrix, and meteoric cementation including early phases of sparry calcite development. The carbonates are subjected to burial (shallow and deep) during mesogenesis, where fragmentation and distortion of grain boundaries and development of point-tangential contacts between allochemical components characterize shallow-burial diagenesis. With increasing burial chemical compaction takes place at higher temperature and pressure symbolized by fracturing, burial cementation, and pressure-dissolution fabrics (stylolitization). During episodic exhumation, telogenesis affects the carbonate horizon by meteoric water, typified by fracturing, meteoric-vadose cementation (fracture-filled sparry calcite cementation, formation of high-temperature polymorph of kaolinite (dickite)), and faint hematite staining. The unfolding of all dissolution, cementation, and dolomitization events are related to allogenic control factors, thereby, being in tune with the high-frequency (low order) stratigraphic framework established for the Bassein carbonates.

Theme 4. General topics in carbonate sedimentology

General Session

Oral presentation

Evolution of Middle Triassic polynucleated, isolated microbial carbonate platforms in the Western Tethys (Dolomites, northern Italy)

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The Western Tethys was characterized in the Middle Triassic by the growth of high-relief, isolated microbial carbonate platforms. Relicts are nowadays exposed in the Dolomites (northern Italy), where original depositional geometries and sedimentological features are well preserved and constrained in a high-resolution bio-geochronological framework. This allows to investigate in detail the evolution of almost every single platform (Sciliar Fm). During multiple field work campaigns, the 'Sciliar platforms' have been accurately investigated and catalogued in a geodatabase inventory, revealing remarkable peculiarities. 74 microbial buildups have been documented to date: they mostly nucleated on topographic reliefs (structural highs or previous platform' tops), during the Late Illyrian, and suddenly aggraded as a response to the rapid, regional sea-level rise. The microbial carbonate factory stabilized the sediment on slopes, reducing the shedding and allowing to develop edifices hundreds of meters thick and up to a few kilometers wide. In surrounding starved basins, disoxic micrites sedimented. The growth of edifices, sometimes laterally asymmetrical, was however suddenly interrupted shortly after: in the majority of cases, pelagic drapes often onlap carbonate slopes, testifying the temporary demise of carbonate platform sedimentation. Collected ammonoids point to a generalized, almost synchronous interruption occurring during the Nevadites ammonoid zone (latemost Illyrian) in the whole region. In some circumstances, carbonate platforms quickly recovered and continued to aggrade, while in others they definitively drowned. The aggrading trend culminated close to the Anisian/Ladinian boundary, when platforms began to laterally expand, as a result of high-standing conditions and decrease in subsidence. The continued widening of edifices allowed survived platforms to merge each other, or in some cases to incorporate demised platforms. The relevance of different factors possibly ruling evolutionary dynamics of Late Anisian platforms, such as the size of carbonate production area, water geochemistry, nutrient availability, sin-sedimentary tectonics, ocean currents or volcanic ash pollution is still under debate. Investigations continue to best define (concurring) key factors.

Theme 4. General topics in carbonate sedimentology

General Session

Oral presentation

The hidden potential of the shallow water record: a large-scale meta-analysis of Palaeocene to Miocene carbonates of southern Tethys

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The changes in carbonate factories over time are the result of evolution and changes to the physical environmental conditions. The two are often hard to separate due to difficulties in tracking large-scale facies changes across time and space in a quantitative fashion. Here we present the result of a standardized re-analysis of some one hundred and fourty-four, Paleocene to Miocene, shallow-water carbonate successions, situated in an area comprised between Levant and Bangladesh. The results indicate that larger benthic foraminifera were the most important group of carbonate producers during the whole period, peaking in the Eocene. Colonial corals, and to an extent red algae, are common during the Paleocene, Miocene and in particular, during the Oligocene; on the other hand, they are essentially absent during the Eocene. Green calcareous algae are the fourth and least abundant group of carbonate producers; their abundance decreases from the Paleocene onward. Patterns of both large benthic foraminifera and colonial corals display a clear connection with global average temperatures, with extremely warm temperatures favouring the former and milder conditions favouring the latter. The similarity between colonial corals and red calcareous algae could be suggestive that, on a large scale, conditions favourable for one group are also favorable for the other, and/or of a positive interaction between the two groups. The progressive decline of green calcareous algae could be related to a preservation bias caused by the transition from Palaeogene assemblages rich of potentially originally calcitic taxa, to Neogene assemblages entirely constituted of aragonitic taxa and thus of limited preservation potential. Carbonate facies related to extremely shallow and/or restricted marine conditions peaked during the Early Miocene with the closure of the Tethyan Seaway. Overall, these results display a significant agreement between the abundance of the various groups of carbonate producers and large-scale processes, showcasing the remarkable potential for paleoenvironmental reconstruction of shallow-water carbonates.

Theme 4. General topics in carbonate sedimentology

General Session

Oral presentation

Fine-grained Cambrian stromatolites in grainstone shoals: selective trapping by microbial mats?

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Stromatolites, laminated structures produced by the trapping and binding of allochthonous sediment and/or precipitation of minerals on microbial mats and biofilms, occur throughout Earth's sedimentary record. Many examples that are fine-grained may have formed by trapping of fine-grained sediment and/or by in situ precipitation of fine-grained fabrics. Here we describe Cambrian examples of fine-grained stromatolites that occur within grained coarse-grained sediments. We studied fine-grained stromatolites enclosed by oolitic packstone-grainstone in the Miaolingian (middle Cambrian) of northwestern China and the Furongian (upper Cambrian) of eastern Canada. At Wuhai, northwestern China, stromatolites up to 2 cm wide and high composed of low-relief cross-cutting fine micritic layers are surrounded by coarse oolitic packstone-grainstone with trilobite fragments and minor grapestone. At a locality near Port au Port, Newfoundland, Canada, fine-grained stromatolites with low-relief cross-cutting micritic layers alternating with keratolite (keratose sponge carbonate) form small columns, both of which are surrounded by coarse sediment. In both examples, coarse sediment is very scarce within the stromatolite, and only accumulated in small intra-column pockets. These examples show low-angle cross-cutting layers consistent with trapping and binding of fine-grained allochthonous sediment, without clotted-peloidal fabrics typical of in situ precipitation. If they accumulated by trapping and binding sediment then this process must not only have been selective for carbonate silt and mud, but it must also have excluded sand-sized grains. Stromatolites of this type occur today in peritidal shoreline conditions around islands in the Bahama Banks where cyanobacterial mats entrap sediment "selectively for the smallest grains in suspension" (Black 1933, p. 176). In our Cambrian examples this interpretation is supported by the presence of the filamentous cyanobacterial fossil *Girvanella* encrusting silt-sized allochthonous grains. These results suggest that it may be possible to recognize selective trapping in fine-grained ancient stromatolites.

Reference

Black, M., 1933. The algal sedimentation of Andros Island Bahamas. Phil. Trans. R. Soc. London. Ser. B, Bio. Sci., 222, 165–192.

Theme 4. General topics in carbonate sedimentology

General Session

Oral presentation

How to build a thrombolite: Late Cambrian examples in Texas

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Thrombolites, 'cryptalgal structures related to stromatolites, but lacking lamination and characterized by a macroscopic clotted fabric' (Aitken, 1967, Journal of Sedimentary Petrology, 37, 1163–1178), are conspicuous in Late Cambrian and Early Ordovician shallow marine carbonates, but often have poorly preserved microfabrics. This can create uncertainty about whether their fabrics are primary or secondary, and whether the clots occur within microbial carbonate or are surrounded by matrix. As a result, thrombolite formation is often poorly understood. Well-preserved Late Cambrian examples in central Texas include (i) maceriate domes and (ii) columns with laminated rims and complex 'thrombolitic' cores (Lee & Riding 2023, Sedimentology, 70/2, 293–334). Maceriate domes have an anastomose microstromatolite framework with millimetric calcimicrobial (*Renalcis*, *Tarthinia*) clots. Laminated column rims are formed by innumerable aligned millimetric microstromatolites. The interiors of small columns contain sediment with centimetric clusters of microstromatolite dendrolite. Larger columns contain ragged stromatolite columns, probably including keratolite, and matrix with burrows emphasized by early dolomitization. Columns and domes together form current aligned biostromes. In external morphology these can resemble present-day examples (Khanna et al., 2020, Marine Petrol. Geol., 121, 104590), but are largely composed of quite different and mainly in situ components, most notably microstromatolites. Microstromatolites, the key component, somewhat resemble Proterozoic microdigitate stromatolites, but are generally smaller, less regular, and appear more biotic in origin. The columns provided substrates for lithistid, and probably also keratosan, sponges. Overall, these generally well-preserved examples show how an array of stromatolite, dendrolite, thrombolite and maceriate macrofabrics could be produced by microstromatolites in combination with calcimicrobes, micritic stromatolites, possible keratosans and allochthonous sediment.

Theme 4. General topics in carbonate sedimentology

General Session

Oral presentation

The puzzle of 'molar tooth structure': geochemistry, origin and significance of calcite microspar cements

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The unusually widespread abundance of the mysterious early diagenetic 'molar-tooth structure' (MTS) is a characteristic feature of pre-Cryogenian Proterozoic carbonate rocks. MTS are ribbon- and sheet-like structures filled with equant, polygonal, tightly packed calcite microspar cement that is exceptionally abundant in Mesoproterozoic and early Neoproterozoic subtidal storm- and microbially-influenced marine environments. MT voids might not be unique as similarly shaped cracks can be observed in other parts of Earth's rock record. However, the early-lithified cavity-filling calcite microspar cements (CMC) (Zhou et al., 2020) make the MTS unique and age diagnostic. CMC is thought to be a synsedimentary precipitate, little altered by diagenesis (Bishop et al., 2006; Pollock et al., 2006), and so has been used widely for geochemical analysis and the reconstruction of Precambrian ocean chemistry. So far MTS CMC has been reported from sedimentary successions dating from ~2600 to ~720 Ma, and can be extremely abundant in some successions. For this study CMC was compared both petrographically and geochemically with the surrounding 'bulk' carbonate rock matrix in Tonian successions on the North China craton. Trace elements, stable isotope $\delta^{13}C$, $\delta^{18}O$ and $\delta^{7}Li$ values, and $^{87}Sr/^{8}8Sr$ comparisons 1) reveal that MTS CMC commonly preserves a primary seawater isotopic signature; 2) indicate that matrix or bulk carbonate material, carefully selected, can also have high potential for seawater geochemical and isotopic reconstruction, for example $\delta^{7}Li$ and $^{87}Sr/^{88}Sr$ values; 3) allow us to test existing models of MTS and CMC formation; and 4) shed light on the reasons for the puzzling disappearance of these mysterious early marine cements in relation to the evolving chemical composition of the Precambrian ocean.

References

Bishop J.W., Sumner D.Y. and Huerta N.J. (2006). Sedimentology 53, 1049–1068.

Pollock M.D., Kah L.C. and Bartley J.K. (2006). Journal of Sedimentary Research 76, 310–323.

Zhou Y., Pogge von Strandmann P.A.E., Zhu M., Ling H., Manning C., Li D., He T. and Shields G.A. (2020). Geology 48, 462–467.

Theme 4. General topics in carbonate sedimentology

General Session

Poster presentation

The Late Thanetian demise of coral reefs in the Hazara Basin (Pakistan)

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The Paleocene–Eocene Thermal Maximum (PETM) was a period of rapid and significant global warming that occurred around 56 million years ago. During this time, the sea-surface temperature increased by 5–8°C, leading to major changes in global climate, ocean chemistry, and marine ecosystems. One of the most significant impacts of PETM was the disruption of coral reefs. Coral reefs are highly sensitive to changes in water temperature, chemistry, calcium carbonate availability, and other environmental factors, as highlighted by the current decline of many symbiont-bearing corals negatively affected by the ongoing rise of global temperatures. We here examine the upper Thanetian shallow-marine carbonates of the Hazara Basin (Ghumanwan section) to document the response of colonial corals to late Paleocene warming. The base of the investigated succession is characterized by larger foraminiferal packstones with patches of colonial-coral framestone and it is referred to SBZ-3 (i.e., late Selandian–lower Thanetian). Upsection, the large benthic foraminifera assemblage can refer to the transition between assemblages SBZ3/SBZ4 (i.e., middle–late Thanetian), colonial corals decrease, while the importance of larger foraminifera and coralline algae increases. A comprehensive comparison between coeval platform carbonates of the Western Tethys (Pyrenees) and of the Eastern Tethys (Hazara Basin, Himalayas) is made to highlight recurrent patterns of carbonate systems in the two regions. The decrease in colonial corals could be related to the late Paleocene–early Eocene increase in global temperatures, which also favored more tolerant carbonate producers such as larger foraminifera.

Theme 4. General topics in carbonate sedimentology

General Session

Poster presentation

Global shelfal carbonate factory, processes and patterns

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Controls over shallow water (0 to 150 m) allochem assemblages, a key element of carbonate facies, have long been a contentious topic. At times with multiple conflicting interpretations to the same assemblage. Hydrodynamic, abiotic and biotic parameters have all been invoked to explain the variability of recent and ancient carbonate facies. To resolve this issue, a reevaluation of the connection between environmental variables and allochem assemblages may be called for. To achieve this, we embarked on a comprehensive review of existing knowledge on the composition of recent carbonates and their conjugated environmental settings. With a database of several thousand data points, we set out to test the asses relevance and impact of main environmental variables on allochem assemblages. Global allochem distribution does not exhibit a single relationship with any one single parameter (environmental or within the assemblage), but a rather complex interaction of multiple variables. Each group of allochems exhibits its own gradient across variable space, with light availability and temperature commonly being the most significant. Some uncertainty limits more refined interpretation as available date sources exhibit inconsistencies in methods and terminology between sources. For example, separation between symbiont-bearing large benthic foraminifera and heterotroph small benthic foraminifera. These require detailed analysis and development of guild concepts to lump allochems together in order to overcome these limitations. Certain groups (e.g., symbiont-bearing colonial corals, halimeda, sessile suspension feeders) clearly display a sharp decline across thermal ranges. However, this decline is a gradient rather than a clear cut-off. Allochem assemblages exhibit no clear separation between C-type and T-type factories, but rather a gradual change across both latitude and water depths. The clear correlation displayed between the composition of the allochem assemblage and the environmental variables highlights the potential for developing general descriptive functions useful for both palaeoenvironmental reconstructions, baseline assessment for conservation and modelization of recent shelf environments.

Theme 4. General topics in carbonate sedimentology

General Session

Poster presentation

Research methods and exploration significance of ancient water systems of carbonate buried hill

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The Ordovician carbonate buried hill in the Tarim Basin mainly has two kinds of ancient water systems: surface and underground water system. The characteristics of surface water systems in the middle of Tarim Basin are obvious, but the distribution range is relatively limited, while in the northern area, they are widely distributed, and most of them are distributed in a tree shape, and gradually converge to the south. Paleogeomorphic restoration, coherence slice and frequency mixing techniques can accurately identify the distribution range of ancient surface water system. The frequency mixing technology can effectively improve the resolution effect of the frequency division result attribute of a single frequency, and is more effective in identifying the ancient groundwater systems. The underground water systems control the distribution of large karst cavity, and poses significant impact on the formation of top large collapse fractures due to cavity collapse in later burial stage. Due to the change of geological environment, the preservation of underground water system is extremely incomplete, and it is difficult to identify and trace directly in seismic data. Only under the guidance of geological genesis, frequency division technology can be used to consider the energy, shape and position relationship with surface water system to find its residual characteristics. Although the preservation is extremely incomplete, the residual part is still one of the most favorable reservoir types at present, especially the roof collapse caused by the cave under the pressure of the overlying huge thick formation. The fracture area formed by this collapse is large, and it is an effective reservoir space. The surface water system is dominated by erosion at high part of buried hill, and lateral and vertical corrosion at low part. For the surface water system, the carbonate rocks in the river beds on both sides are diagenetic early and hard, while the river channel sediments are relatively diagenetic late and hard. The overlying Ordovician carbonate rocks may form fractures along the ancient water system due to differential. The study on ancient water systems is of great significance to predict the distribution of karst, deepening the study of non-tectonic fractures and expanding exploration scope of fractured reservoirs.

Theme 4. General topics in carbonate sedimentology

General Session

Poster presentation

Palaeoenvironmental and stratigraphic reconstruction of the Early Eocene foraminiferal limestone of Pag Island (Croatia)

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Biogenic carbonate successions provide a trove of proxies for palaeoenvironmental reconstructions. Skeletal and faunal assemblages, stable isotopes and abundance of terrigenous fractions provide information on relevant parameters such as palaeobathymetry and palaeotemperatures. A quantitative approach in their analysis can produce detailed reconstructions of past environments and allow for an easy and reliable comparison of different successions. Benthic foraminiferal assemblages are particularly suited for this task: they provide reliable palaeoecological proxies; they are globally distributed; they are usually abundant also in small samples (both in sediments and rocks successions); and they display short reproductive cycles useful to track environmental changes over short time periods. Benthic foraminifera are also useful for stratigraphic analyses of shallow carbonate successions. In order to assess the full potential of foraminiferal-based palaeoenvironmental reconstructions, we have carried out analyses on the Early Eocene limestone succession of the Island of Pag (western Croatia), within the Dinaric Foreland Basin. The combination of palaeontological and sedimentological studies allowed to reconstruct the dynamics of the Eocene carbonate factories of the basin, to clarify the role of the main carbonate producers of the Early Eocene (large and small benthic foraminifera, calcareous red algae and corals) and to provide information about the geodynamic setting of the Dinaric Alps. The analysis was based on quantitative parameters derived from benthic foraminifera assemblages, which provided valuable information on palaeobathymetry, palaeotemperature, nutrient regime, transport and conditions at the seafloor (e.g., possible presence and extension of seagrass or seaweeds meadows). The point-counting technique was also used to obtain a complete characterization of the skeletal assemblage. This approach allowed to build a reliable model for the successions, to obtain data that can be easily compared with those of other carbonate successions of the Eocene, and to make a step forward in the comprehension of Cenozoic carbonate factories and their evolution in the Tethyan area.

Theme 4. General topics in carbonate sedimentology

General Session

Poster presentation

Mg-rich brine seeps in the Burgess Shale Lagerstätte constrained by dolomite U–Pb geochronology

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In the southern Rocky Mountains of western Canada, the Burgess Shale (Middle Cambrian) contains world-class examples of the earliest arthropods, molluscs, annelids, and chordates; often with the preservation of soft-bodied material as carbonaceous remains. Over a century of research has been conducted since Charles D. Walcott's discovery of the lagerstätte in 1909, with several other "Burgess Shale-type" deposits later documented worldwide. Nevertheless, the controls on the occurrence and distribution of lagerstätten remain enigmatic, particularly why such incredible concentrations of biota thrived at these times and in these locations. Coeval and adjacent to the Burgess Shale, a shallow-water succession of carbonate sedimentary rocks has been extensively altered by fault-controlled, hydrothermal dolomitization; with local clinochlore, talc, and magnesite mineralization along the margin of the carbonate platform. The timing of such hydrothermal activity, however, is contentious, with interpretations that range from the Middle Cambrian to the Late Cretaceous. Here we show, using U–Pb geochronology, that the timing of dolomitization in the southern Rocky Mountains was syn- and early post-depositional (Middle Cambrian to Early Ordovician). Surface-breaching faults along the platform margin facilitated the mixture of Mg-rich crustal fluids with seawater, locally forming standing brine pools in paleo-topographic lows on the seafloor. Although chemotrophic activity within these deposits was likely minimal, the Mg-rich brine seeps increased nutrient availability and promoted microbial productivity. This increased microbial productivity resulted in the concentration of heterotrophic megafauna along the peripheries of the brine pools. Such highly saline pore fluids would have also inhibited bioturbation and the scavenging of organic material in the sediment, thus promoting Burgess Shale-type preservation. The results of this study challenge the common models of lagerstätten development, while also providing valuable insights into fundamental processes of dolomitization that can be applied to sedimentary basins worldwide.

Theme 4. General topics in carbonate sedimentology

General Session

Poster presentation

Relationship and interaction of carbonate bioclastic sediment and *Posidonia oceanica* in case of two Croatian pocket beaches

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Measured by their total length, beaches on the Croatian coast are not ubiquitous depositional environments. Sandy beaches are less common compared to gravel beaches, while bioclastic carbonate beaches are a rarity. The production, deposition and maintenance of bioclastic carbonate sediment on beaches is often related to the presence of seagrass meadows. Due to increasing natural and anthropogenic pressures, beaches are at risk from erosion. However, the increased proportion of bioclastic carbonate material in beach sediments requires a detailed analysis of beach dynamics in relation to sediment supply. Several methods, including basic sedimentological analysis, biogeomorphological characterization, beach profiling, and digital photogrammetry were applied to two pocket beaches, Sakarun and Lojišće (Dugi otok Island), during a one-year monitoring period to investigate the relationship between bioclastic beach sediment production, beach erosion, and maintenance with the presence of *Posidonia oceanica* meadows and its banquettes. The Sakarun beach is a semi-rural beach that is seasonally exposed to extreme anthropogenic pressure. The emerged part of the beach consists mainly of gravel. Thin bioclastic carbonate sandy veneer occurs in the lower supratidal and intertidal zones and become thicker in the submerged part of the beach. The sediment dynamics of the beach are directly related to prevailing SE wind waves. *Posidonia* banquettes here are natural biogeomorphological structures impregnated with sediment. Their removal also removes some part of the beach sediment and promotes more rapid erosion after storms. Lojišće beach is a natural remote beach, less affected by tourist activities. It consists entirely of bioclastic carbonate sand deposited by the same prevailing SE waves. It showed higher stability in the context of erosion and general sediment dynamics, while *Posidonia* banquettes showed the same biogeomorphological role on the beach. The production of bioclastic sediment on both beaches is closely related to the *Posidonia* meadows in front of their bays, while the sediment supply of the beach depends on the prevailing waves. The same mechanism is responsible for the formation of banquettes. The management of banquettes should be considered in future coastal erosion control.

Theme 4. General topics in carbonate sedimentology

General Session

Poster presentation

Carbonate platform margin to foreland basin evolution in the Pre-Karst Unit of the Dinarides (Gacko, Bosnia and Herzegovina)

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The Pre-Karst unit in the Dinarides represents a transitional paleogeographic domain between the carbonate platform environments of the High-Karst unit and more internal, dominantly deep-water environments of the subsided Adria margin. Exposures near Gacko in Bosnia and Herzegovina offer a glimpse into the evolution of this domain during the gradual closure of the Neotethys ocean and progressive orogenic advancement in the Dinarides. The base of the studied section is composed of carbonate breccias of presumably Late Jurassic to Early Cretaceous age, with lithoclasts of older Jurassic limestones. These are overlain by poorly bedded to massive Barremian–Aptian carbonate breccias with a packstone–grainstone matrix comprising peloids, benthic foraminifera, and skeletal fragments of various shallow-water organisms. This interval is interpreted to have been deposited in a shallow-water carbonate ramp environment with variable bathymetry. Grain-supported intervals with lithoclasts and various bioclasts represent higher energy environments deposited on a steeper slope, as opposed to micrite-supported intervals with sparse bioclasts. These deposits are unconformably overlain by shallow-water to slope deposits, beginning with a massive bioclastic floatstone–rudstone interval composed mainly of rudist bivalve shells. Upwards the succession changes into a well-bedded alternation of calcilutites, calcarenites, and calcirudites containing pelagic foraminifera (indicating a Santonian age), skeletal fragments of shallow water organisms, and lithoclasts. They formed in a slope apron environment characterized by finegrained periplatform deposition, soft sediment deformations and coarse-grained resedimented shallow water material resulting from episodic gravity flows. By the Maastrichtian, sedimentation conditions changed with an introduction of siliciclastic material and megabreccia deposits suggestive of active tectonics and foreland basin development.

Theme 5. Continental clastic depositional systems

Special Session 5.1. Lake sediments as archives of natural and anthropogenic changes in climate and the environment

Oral presentation

Paleoenvironmental and paleoclimatic evolution in Jura lakes since the Late Glacial period

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Numerous glacial paleolakes took place in the French and Swiss Jura during the retreat of Würm ice sheet. Two sites were investigated: the Amburnex Valley site (Switzerland) and the Lake Val (France). During the Late Glacial period, both sites were glacial lakes characterized by significant accumulation of lacustrine sediments allowing a better and complete paleoclimatic and paleoenvironmental evolution record. The main goal of this study is to reconstruct the paleoclimatic and the paleoenvironmental evolution recorded in lacustrine sediments deposits since the last 15,000 years. The Amburnex core exhibit a basal morainic deposit from the Würm period, overlain by three meters of lacustrine deposits and four meters of peatland deposits. The Lake Val core consists of the same lithological succession. A multiproxy approach based on palynological, mineralogical and geochemical analyses (TOC, Nitrogen, Phosphorus and Mercury contents; major and trace elements; organic carbon isotopes) have been used to characterize the hydrological and climatic fluctuations, the trophic level and the origin of organic matter in order to reconstruct the paleoenvironmental and paleoclimatic evolution of this area. The Bølling–Allerød, the Younger Dryas and the beginning of the Preboreal period have been recognized in the Amburnex site, by palynological analyses and carbon 14 dating. During the Oldest Dryas, oligotrophic conditions took place as suggested by the very low concentrations in nitrogen and organic matter. Then, during the warmer Bølling period, an enrichment in total organic carbon (TOC) implying the development of eutrophic conditions. Later in the Allerød period, low TOC and phosphorus contents, associated with varved carbonate deposits, indicate a return to more oligotrophic conditions. New organic matter enrichments are observed in the interval corresponding to the colder Younger Dryas period. These trends are quite consistent with those observed in the Lake Val and reflect significant changes in runoff and nutrient inputs at least at regional scale.

Theme 5. Continental clastic depositional systems

Special Session 5.1. Lake sediments as archives of natural and anthropogenic changes in climate and the environment

Oral presentation

Paleotemperature shifts revealed by seasonal halite records from the Dead Sea Basin during interglacial period MIS 7c

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Temperature-hydroclimate relationships, based on proxy data from sediment records, are essential to understand regional-to-global climate dynamics. Deep-marine sediment records are available for nearly low-mid latitudes while ice cores cover high latitudes. Terrestrial climate archives, however, are in comparison spatially and temporally poorly distributed. In arid desert-like regions such as the Levant, temperature proxy records used for hydroclimate reconstructions (i.e., evaporation, rainfall) are scarce and commonly derived from traditional stable oxygen isotopes or pollen data at low resolution. Recent methodological advances using Brillouin spectroscopy (BS) are now allowing us to directly measure entrapment temperatures (corresponding to subsurface temperature) of fluid inclusions (FIs) in salt deposits (i.e, halite), which mimic the composition of the parent brine.

Here we report a seasonal-derived lake temperature record of the hypersaline Dead Sea basin (DSB) for the mid-Pleistocene interglacial period MIS 7c (ca 215 ka). We sampled an entire varved halite section (13 layers of both cumulate and coarse halite deposits) in DSDDP core 5017-1 which represents holomictic lake conditions. FIs data from coarse halite layers, representing spring-to-summer seasons, show the decadal evolution of the hypolimnion after and before the return of meromictic conditions. Paleo deep lake temperatures range from 17.7 ± 1.4 °C to 22.7 ± 1.0 °C along the core section, respectively, with the latter being close to modern minimum hypolimnion values in the Dead Sea. The dataset provides insights into major seasonal shifts of the lake system, including a mean temperature change of -0.8 and +1 °C during winter and summer, respectively. Supported by *in situ* studies in the modern DSB, we interpret coarse-top samples as minimum hypolimnion temperatures during late summer times, while coarse-bottom samples reflect accurately the hydroclimatic conditions during winter-to-spring times in the DSB. Our results illustrate the large potential of varved halite layers in core 5017-1 as seasonal paleorecords during drier regional-to-global climate conditions. They further show the potential application of this approach to similar evaporitic sequences at different geographical and temporal scales.

Theme 5. Continental clastic depositional systems

Special Session 5.1. Lake sediments as archives of natural and anthropogenic changes in climate and the environment

Oral presentation

The Atlantic multidecal variability recorded in a varved sequence in eastern Canada

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Natural archives of climate offer a longer perspective into natural climate variability than the instrumental record. Varved sediments are rare, but valuable records because of the quality of their internal chronology. Grand Lake, located at the eastern margin of North America in Labrador, is a deep lacustrine basin that contains an exceptionally well-preserved annual laminations record spanning the interval 493 to 2016 CE (1524 years). The chronology of this varved sequence is established from high resolution images analysis of thin sections. ^{137}Cs and ^{14}C dating is also used to validate the reliability of the varve chronology. The statistically significant correlation between varve thickness and the measured discharge of the main tributary provides the opportunity to develop the first hydrological reconstructions covering the last fifteen centuries at the western fringe of the North Atlantic Ocean. The reconstruction indicates that the river discharge was higher during the Medieval Climate Anomaly (1050–1225 CE) and lower during the Little Ice Age (15th–19th centuries). It also shows a significant co-variability with Atlantic Multidecadal Variability reconstructions and with reconstructed summer Northern Hemisphere temperature based on tree rings. This suggests that river discharge in Labrador was influenced by ocean–atmosphere interactions across the North Atlantic. Seismic profiles also reveal that the infill in the deep basin of Grand Lake is continuous, undisturbed and more than 40 metres thick, raising the prospect of an annually resolved record of the North Atlantic large-scale modes of climate variability over most of the Holocene.

Theme 5. Continental clastic depositional systems

Special Session 5.1. Lake sediments as archives of natural and anthropogenic changes in climate and the environment

Oral presentation

Supply-induced transgression in endorheic lakes: a fundamental difference between lacustrine and marine settings

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Palaeo-lakes are important climate proxies, and they host a large portion of the world's geo-resources, including fresh-water reserves, therefore understanding lacustrine basin fill pattern is crucial. Like in marine systems, the depositional architecture is determined by water-level variations. However, in hydrologically closed – endorheic – lacustrine settings, where the water-level is disconnected from the seas, instead of eustasy, water balance is mostly driven by climatic forces, such as the interplay between precipitation and evaporation. Commonly local structural movements are also regarded as important controls on the evolution of lake-level. This study emphasizes the main differences between marine and lake systems and the possible pitfalls of working in endorheic settings.

To better understand the different driving mechanisms on water-level changes, a diffusion-based numerical modeling tool, DionisosFlow has been applied. A series of source-to-sink models with an area of 800x400 km has been conducted to analyze the effect of climatic variations, subsidence, compaction, and sedimentation in large, deep, supply-dominated lake basins. These lacustrine models are compared to their marine counterparts. These conceptual models are constrained by seismic-scale observations from the Late Miocene Lake Pannon, a large, enclosed, long-lived water body.

In the models the lacustrine system responds rapidly to any perturbation in evaporation and precipitation. The lake-level is controlled by the extension of the steady-state lake surface and the dip angle of the shore. Our models infer that variable subsidence rates have limited effect on the equilibrium lake surface; therefore, water-level is principally governed by climate. When applying fluvial sediment input, deposition takes place from deltas, through shelf-margin wedge to the deep basin. A long-term water-level rise occurs in correlation with the increasing area of the coastal plain due to the basinward shift of the shoreline. This results in an overall aggradational stratigraphic architecture. In contrast to marine systems, where sedimentation does not influence relative sea-level, lake-level rise is induced by normal regression driven by sediment supply.

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Theme 5. Continental clastic depositional systems

Special Session 5.1. Lake sediments as archives of natural and anthropogenic changes in climate and the environment

Oral presentation

Sedimentary responses to the climatic and environmental variations recorded from lake Karif Shawran in the southern Yemen

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The Arabian Desert is considered a climatic sensitive zone which is susceptible to changes in the Indian monsoon fronts. Its unique location offers a valuable opportunity to study the interactions between monsoons, shifts in the Inter-Tropical Convergence Zone, and regional environmental changes. Lake sedimentary archives from the southern Arabian Desert are scarce, making it crucial to understand climatic and environmental changes during the mid–late Holocene. This study aims to determine the onset and periodicities of climatic events in southern Yemen through an interpretation of multiproxy applied to a sediment core (JAS) from the maar lake Karif Shawran. A composite 1 m long core (JAS) was analyzed using geochemical, mineralogical and biological proxies to reconstruct past global changes and provide information on the surrounding environment and climate history. The chronology of the JAS core is based on four radiocarbon ages from ostracod shells and consists of lamina-scale alternations of halite and organic detritus layers with occasional turbidite and ash layers. The μ-XRF data reveal higher values of Ca counts and decreased K/Ti values from ~2000–3200 BP, 1100–1600 BP, and ~200–450 BP, indicating lower lake levels. Furthermore, increased inorganic carbon and decreased magnetic susceptibility values in the same interval further corroborate evidence of drought in the region. The drier intervals are marked by higher values of Paq (n-alkanes proxy), suggesting growth in aquatic macrophytes in response to the declining lake levels. Moreover, the ostracod assemblage revealed the presence of a single euryhaline species, *Cyprideis torosa* in the sedimentary record. Ecophenotypic variation of *C. torosa* valves provided some useful paleolimnological information, such as the variability of salinity ranges in the lake water. The study provides key insights into the major driving forcing (Solar, Volcanic or ENSO) behind hydroclimatic changes in the region and sheds light on the role of the ITCZ vis-à-vis monsoonal dynamics. Additionally, it lays the foundation for a better understanding of long-term seasonal predictions for Southern Arabia.

Theme 5. Continental clastic depositional systems

Special Session 5.1. Lake sediments as archives of natural and anthropogenic changes in climate and the environment

Oral presentation

Cyclical and non-cyclical stratigraphy in Pliocene lakes of the East African Rift System

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In an attempt to distinguish the impacts of climate from tectonics and volcanism on the Pliocene lake-basin record of the East African Rift System, we examined two successions represented by both outcrop and core in the Baringo Basin, Kenya Rift, and the Northern Awash Basin of Afar, Ethiopia. Detailed sedimentology, ichnology, and sequence stratigraphy, aided by paleoecological, mineralogical, and geochemical records of lake conditions, were used to recognize cyclical packaging in these separate rift basins through varying phases in their development. Time-series analysis was used to demonstrate the observed cyclicity where present. Major changes in lake-basin type (e.g., underfilled, balanced fill) were interpreted by integrating sedimentological data with other available paleoenvironmental datasets, and were considered in the context of longer-term orbital cycles, as well as periods of faulting and/or volcanism. Statistical analysis of cycle thicknesses ("depth series" analysis) was used to help demonstrate interpreted changes in basin development, by revealing variable sedimentation/subsidence rates. Cyclical lake-level fluctuations in these shallow, volcanically and tectonically active rift basins are represented by predictable packages of sedimentary facies (~6–10 m thick), which vary depending on lake conditions, but all contain relatively deep to shallow lake and lake margin deposits. Distinct, thicker portions of the successions (~40–100 m thick) represent stacked sets of transgressive–regressive cycles. Orbital cycles (e.g., precession, eccentricity) correspond well to the predictable, although variable, thinner packages, but major non-cyclical changes in facies associations appear to not be well explained by orbital forcing of climate. Detailed sedimentology is essential for recognizing cyclicity in the successions studied, and is particularly critical in mud-dominated packages where other records do not exemplify cyclicity. Through the recognition of repetitive packaging in depositional environments from profundal to terrestrial, regardless of specific lithofacies, we can start to better distinguish climate influences from basin-scale controls on the stratigraphy in these rift lake-basins.

Theme 5. Continental clastic depositional systems

Special Session 5.1. Lake sediments as archives of natural and anthropogenic changes in climate and the environment

Oral presentation

Pliocene environmental conditions in the Levantine Corridor (Near East): perceptions from a multi-proxy study on a lacustrine record

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The Pliocene was the last significant sustained warm period in Earth climate history. Atmospheric carbon dioxide and global temperatures during this interval are comparable to those modeled for the near future. Considering a similar to current continental and oceanic positioning, it is possible to assume similar oceanic and atmospheric circulation patterns, and hence reliable climate archives dated to this interval may serve as a good analogue for providing a base of comparison to the future. Current data on the Pliocene mostly focus on marine sediments with terrestrial data arriving from loess and paleosol records. Yet, there is a lack of information from continental datasets, especially from the Eastern Mediterranean. The Erk'-el-Ahmar Fm. (3.15–4.5 Ma) is a ~150 m lacustrine succession exposed in the Jordan Valley and includes clay to very find sand layers with carbonate units and excellent preservation of freshwater mollusks, ostracods, and mammal bones (rodents and even a mammoth tusk). This study aims to reconstruct the environmental conditions in the region during this time interval using a multi-proxy approach that includes physical, chemical, and biological measurements carried out on a 23 m long push-core. Our results show major fluctuations in the lake hypsometry, as evidenced by the different parameters, which appear to reflect the local hydro-climate conditions. An orbital-scale dry-wet climate cycle is well identified, which influenced the lake depth, its redox conditions, and sedimentary provenance. The sediment cores capture transitions between a continuous deep to a shallow lacustrine environment, with potential short intermittent events (perhaps seismic or climate-induced), indicating the sustainability of this perennial water body. Results from this study provide an important understanding of the hydrological conditions that may have dominated the region during a warmer climate phase, challenging previous estimations on the governing mechanisms for climate variability in the region including precipitation patterns.

Theme 5. Continental clastic depositional systems

Special Session 5.1. Lake sediments as archives of natural and anthropogenic changes in climate and the environment

Poster presentation

Limnological responses to human activity: an example of varved record of Lake Lubińskie (western Poland)

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Varved sediments from Lake Lubińskie (western Poland) were investigated to determine limnological responses to environmental changes over the last 3,000 years based on multiproxy analyses of a 5 m-long sediment record. More specifically, the aim was to identify the primary driver of changes recorded in varve structures and compositions. To achieve this goal, a set of sedimentological, geochemical, and isotopic methods along with Bayesian age–depth modelling and change point analysis were used. To get an overview of the changes in lacustrine communities and land use, diatom and pollen analyses were performed enabling us to demonstrate a history of ecosystem changes.

Our data show, that the five major microfacies can be distinguished in the profile, which represents different conditions of the lake. Until the 4th century of the Common Era, conditions in the lake were stable, although it seems that the lake was naturally eutrophic. Several further shifts occurred before the first millennium when changes were observed in every proxy as a response to the increased agricultural development in the area, related most likely to the Emergence of the Polish State at the beginning of the 11th century. The progressing anthropogenic stress caused shifts in diatom communities towards those with an affinity to higher water pH and trophy as well as change in varve composition and preservation, leading to varve cessation at 1458 ± 96 CE. The varves reappeared around 1748 ± 80 CE most likely as an effect of human-derived eutrophication. The highest frequency of shifts, however, was observed from the 17th century onward as an effect of prolonged deforestation, accelerated erosion, increased nutrient delivery, and better ventilation of the water body. Our study suggests that inferred lake-level changes are primarily related to human activity in the catchment area.

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Special Session 5.1. Lake sediments as archives of natural and anthropogenic changes in climate and the environment

Poster presentation

Holocene lacustrine paleoenvironmental evolution from Cameroon lakes (SW Africa)

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Lakes are the most attractive and expressive characteristics of a landscape. Lacustrine sediments provide a historical record of the conditions of catchment environments. They are highly sensitive to paleoenvironmental change. The aim of this study is to reconstruct the paleoenvironment of 3 lakes located in Yaoundé, Dizangué and Ngaoundaba regions (Cameroon, SW Africa) for the last 1000 years using a multiproxy approach including sedimentology, mineralogy, geochemistry, radiocarbon dating, diatoms and palynology. Sediment samples were taken from a raft and polyvinyl chloride (PVC) pipes They generally consist of sub-rounded and sometime rounded particles indicative of both aeolian and medium fluvial transport. Their physical and chemical features suggest both proximal and distal origins. The presence minerals such as quartz, kaolinite, smectite, hematite, goethite, feldspars, rutile and calcite with traces of illite, vivianite and ilmenite suggest high weathering under warm and humid conditions. According to geochemistry, the sediments derived from felsic, intermediate and mafic rocks from nearby granitic, gneissic and basaltic rocks. Weathering indices indicate high intensity of alteration related to both active and passive margin tectonism. Element ratios indicate a low compositional maturity in an oxic depositional condition and low salinity paleoenvironment. These sediments were deposited in a shallow marine and fluvial depositional environments with an increase water depth environmental condition. According to radiocarbon dating, the studied sediments are Holocene in age. Palynological and diatom data reveal major hydrological changes, which occurred over the last 1000 years, mainly characterized by strong fluctuations in wet and dry conditions during the “Medieval Warm Period” (1100–800 yrs BP) and dry conditions during the “Little Ice Age” (500–300 yrs BP). These hydrological changes have controlled the dynamics of tropical rainforests in this part of Africa, resulting in their expansion during periods of heavy rainfall and contraction during periods of reduced rainfall.

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Poster presentation

Environmental implications of nodular carbonate-bearing fluorapatite (CFA) in the lacustrine shale of the Shahejie Formation, Dongying Depression, Bohai Bay Basin: insight from petrographic and geochemical analysis

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A varying abundance of CFA nodules in lacustrine shale in the Bohai Bay Basin was observed as a specific paleoenvironmental proxies. We specified the petrology, trace elements (TE), rare earth elements and yttrium (REY) by using an integrated approach of micro-FTIR, LA-ICP-MS and EPMA analysis. The results suggest that CFA nodules are mostly with diameters of 0.46 to 18.3 mm (avg. 2.3 mm), and aspect ratios of 0.05 to 1.01 (avg. 0.48). CaO (25.85 to 39.95 wt.%), P_2O_5 (17.19 to 29.35 wt.%) and F (0.71 to 2.99 wt.%) are the dominant components of the CFA nodules, with low Mn/Fe ratios and few incorporations of CO_3^{2-}. They show selective concentrations (avg.) of Sr (14963.3 ppm), Ba (1831.6 ppm), U (314.2 ppm), Zr (263.5 ppm), and Th (185.4 ppm) and apparent negative Y anomalies with low Y/Ho ratios (18.40 to 28.90). These CFA nodules were classified into three types according to REY patterns normalized to PAAS. Type A nodules, enclosed by micritic calcite laminae with relatively large aspect ratios, are middle rare earth elements (MREE) enriched which yield a typical "bell-shaped" REY pattern, nonanomalies of Ce and a good correlation of ΣREY with Ce/Ce* (R^2=0.90) and Ba (R^2=0.95). Type B nodules, enclosed in the clay and organic-rich laminae with relatively small aspect ratios, were better phosphatized and display more heavy rare earth elements (HREE) depletion, minimal Ce anomalies and a good correlation between CaO and P_2O_5 (R^2=0.84) than type A nodules. Type C nodules are rare but show light rare earth elements (LREE) enrichment relative to type A and B nodules. The adsorption of P, TE and REY by Fe-(oxyhydr) oxide and organic matter is significant for CFA formation through the "dissolution–recapture–reprecipitation" process in the ambient pore water of the Fe reduction zone during early diagenesis. The retention of HREE as $HREE(CO_3)^{2-}$ in more reducing bottom water is critical to the HREE depletion for type B and C nodules, while the release of LREE from bacterial-mediated degradation of organic matter into ambient pore water enhances the concentration of LREE on type C nodules. Deviation of the REY patterns is probably related to the differential suboxic redoxclines for the deposition of calcite-rich and clay- and organic-rich laminae of shale, which are considered the depositional environment proxies of lacustrine shale.

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Special Session 5.1. Lake sediments as archives of natural and anthropogenic changes in climate and the environment

Poster presentation

Are diatoms and chrysophyte cysts reliable indicators of meteorological conditions? A case study from eutrophic Lake Żabińskie, northeastern Poland

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The impacts of climate change on aquatic ecosystems are becoming increasingly apparent, with alterations in water temperature, lake mixing patterns, and resource availability. In order to better understand these impacts on diatom and chrysophyte cyst seasonal dynamics and taxonomic composition, we carried out the three-and-a-half-year-long study of biotic sediment signal formation in eutrophic Lake Żabińskie, northeast Poland. We attempted to explain the relationship between changes in meteorological conditions and dynamics of total fluxes and the taxonomic composition of diatoms and chrysophyte cysts by combining observational data of meteorological conditions, water column physicochemical parameters, and modern sedimentation. According to our results, meteorological conditions directly influence physicochemical conditions and indirectly influence diatom and chrysophyte cyst phenology and species succession. Air temperature and wind speed shaping the mixing regime of Lake Żabińskie influence nutrient cycling which further alter diatom and chrysophyte cyst seasonal dynamics. In addition, our study shows that the biotic response to unusually warm winter without ice cover registered in 2020 was different from the pattern in more "typical" years with regard to the phenology of diatom and chrysophyte cyst blooms. Nevertheless, due to the high trophy of Lake Żabińskie, this response was not as pronounced as in lakes of lower productivity. Variations in meteorological conditions also led to the compositional turnover of both diatoms and chrysophyte cysts. The connection between changes in meteorological conditions, lake dynamics, and primary producers' distribution underlined the possibilities and limitations of using diatoms and chrysophyte cysts in climate-related studies and paleoclimatic reconstructions in eutrophic lakes.

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Special Session 5.1. Lake sediments as archives of natural and anthropogenic changes in climate and the environment

Poster presentation

Sedimentary and inorganic geochemistry records of Early Cretaceous paleoclimate fluctuations in lacustrine sediments, Luanping Basin, northeastern China

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The global climate during Early Cretaceous has experienced several fluctuations, which were recorded both in marine and lacustrine sediments. In order to reveal the paleoclimate variation and its effects on paleoenvironment evolution in continental lakes, the outcrops of Lower Cretaceous Luanping Bain in northeastern China were carefully measured for the reconstruction of depositional environment. Besides, mudstone samples collected for inorganic geochemistry analysis were investigated to reconstruct paleoclimate variation. Based on lithology, grain size and sedimentary structures, three lithofacies associations were classified including delta front, shallow lake and deep lake. Weathering index (CIA) and mean annual precipitation (MAP) calculated through CIA revealed that the climate of Early Cretaceous Luanping Bain experienced several fluctuations between warm-humid and cool-semihumid. The mean annual atmospheric temperature (MAT) calculated by sodium chemical depletion (τNa) ranges from -5 °C to 15°C with a mean of 10 °C, which was consistent with the research on East Asia climatic conditions using oxygen isotope composition ($\delta^{18}O$) of apatite phosphate. During cooling event the decrease in temperature and precipitation resulted in the decline of lake level. Low redox conditions index (Th/U) and detritus input index (Zr/Ti) indicate that dysoxic condition with low detritus input occurred. The clastic varves and calcareous lamination deposited in shallow lakes demonstrated seasonal precipitation was prevalent. As temperature and precipitation increased during the subsequent warming event, high detritus input and anoxic condition were developed. The multistorey sandstones with gradational planar lamination and bentonite layer indicated high frequency flood event existed during this period. When paleowater depth reached deepest, black mudstones interbedded with massive dolomite representing deep lake deposits were commonly developed. The climate variation in Early Cretaceous was closely related to the fluctuations of global CO_2 concentration. This study sheds light on the climate effects on depositional environment evolution and prediction of lacustrine hydrocarbon source rocks.

Theme 5. Continental clastic depositional systems

Special Session 5.2. New advances in lacustrine sedimentology

Oral presentation

Seismic prediction technology for "sweet spot" reservoir of glutenite trap and application result

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In the western slope area of Huanmahu sag, Junggar basin, Baikouquan formation develops glutenite trap, and the "sweet spot" reservoir has obtained high-yield industrial oil flow. With the fine analysis of oil–gas reservoir, it is concluded that the main controlling factors of accumulation include favorable facies belt of sandy conglomerate in delta front, thickness of high-quality reservoir, porosity and oil source fault. A new method, namely "five-step-methodology" combing well logging and seismic data, has been proposed to predict the plane distribution range of "sweet spot" reservoir. Firstly, by integrating the geology and geophysics, the forward model analysis is conducted to analysis the relationship between the delta belt, reservoir thickness and features of seismic response, which serves as the technical support for 3D seismic data processing of OVT domain. Secondly, in the 3D seismic data of OVT domain, the isochronous geological surfaces are acquired by utilizing global automatic stratigraphic interpretation technology. The paleo-geomorphology background is then to be recovered by producing formation thickness map and therefore the boundary range of the fan-delta can be delineated by combining single well sedimentary facies and attributes of seismic. Thirdly, by classifying the sandy conglomerate reservoir of fan-delta front, the template of rock physics can be performed. Consequently, the pre-stack inversion is to be conducted to predict the thickness of high-quality reservoir and plane distribution features of porosity. Moreover, to tackle the small distance of fault in the oil source profile, the Eigenvalue of structural tensor matrix has been employed to perform the fracture attribute volume, so as to predict the distribution characteristics of small faults in the section and plane. Lastly, according to the accumulation pattern diagram of Bai 2 member of Baikouquan formation and applying the comprehensive geological analyzing method, the "sweet spot" is generally developed in the overlapping parts of fan-delta front facies, thick high-quality reservoir, large porosity and fault of oil source. Based on the research result, the success rate of preliminary prospecting well reaches above 92%, which is able to serve as valuable reference for the study of similar geological background.

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Special Session 5.2. New advances in lacustrine sedimentology

Oral presentation

Characteristics of high-quality beach-bar sand reservoirs of Permian Lower Urho Formation in Madong area, Junggar Basin

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The drilling results show that the Permian Lower Urho Formation in Madong area has typical beach-bar sand deposition characteristics. In order to explore a new field of hydrocarbon exploration, confirm the planar distribution and exploration potential of beach-bar sand, on the basis of high-resolution three-dimensional seismic data, combined with data collected during drilling, formation testing, well logging and core analyses, the petroleum geological characteristics of beach-bar sand reservoir are systematically analyzed. Finely portrayed the planar distribution pattern of the beach-bar sand in the Lower Urho Formation of the Madong area, and discussed its hydrocarbon accumulation potential, using seismic analysis techniques such as attribute extraction and stratal slicing. The results show that: the target layer of the study area presents apparent characteristics of the beach-bar sand, which is distributed along the shore lake in a strip-like; and it forms good hydrocarbon accumulation condition and has a huge area for exploration. The discovery and confirmation of the "beach-bar sand" field provides a model to shed light on exploration of the "beach-bar sand" oil and gas reservoir across the Madong area, as well as a new exploration frontier for oil and gas exploration in the Junggar Basin.

Theme 5. Continental clastic depositional systems

Special Session 5.2. New advances in lacustrine sedimentology

Oral presentation

Sedimentary dynamics and deposition model of Chang 7 member from the Yanchang Formation lacustrine fine-grained sedimentary rocks in Tongchuan area of the Ordos Basin, China

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To study the lacustrine deep-water fine-grained sedimentary characteristics and depositional models, we take Yishi Village, Yaoqu, and other typical field sections in China as research objects. To make full use of the sedimentological analysis method, the Chang 7 member lithofacies, lithofacies assemblage characteristics and fine-grained sedimentary lithofacies evolution models are systematically studied in Triassic of the Ordos Basin, China. Three points of understanding have been obtained as follows: (1) The outcrops in the middle and lower sections of the Yanchang Formation in the Tongchuan area primarily developed overlying and scouring positive-order silt–fine sandstone, massive bedding silt–fine sandstone, soft sedimentary deformed sand–shale mixed, and massive mudstone facies, horizontal laminated shale facies and tuff facies. (2) The lithofacies assemblage types of the fine-grained sediments in the Chang 7 member from the Yanchang Formation in the Tongchuan area include background argillaceous deposits, vertical assemblages of tuff and gravity flow deposits, superposition of sliding landslides and background mudstones, gravity flow deposits of sandstones and mudstones. The typical characteristics of the Chang 73 sub-member of the Yishicun section are sandy clastic flows and slump deposits with massive bedding. The deep-water in-situ deposits from different outcrop sections of the Chang 72 sub-member, whose lithology transitions from siltstone–silty mudstone to horizontal laminar mudstone to black shale with extremely developed shales. The Chang 71 sub-member of the Yaoqu section is rich in soft sedimentary deformation structures, such as liquefied sandstone veins, argillaceous bands, and flame-like structures in massive sandstones. (3) During the sedimentary period of Chang 7 member, the lake level was found to rise first and then decrease periodically. The fluctuation of lake level controls the transport mode and deposition mode of fine-grained sediments and has important guiding significance for the study of the transport mechanism and distribution of fine-grained sediments.

Theme 5. Continental clastic depositional systems

Special Session 5.2. New advances in lacustrine sedimentology

Oral presentation

Fluid–rock interaction and pore formation in deep clastic reservoir

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The fluid–rock interaction in sedimentary basins is an important factor affecting the formation of deep pores and the accumulation of oil and gas. The study of corrosion response and process under the background of different oil and gas filling intensities is very important for reservoir evaluation. Taking Wuerhe formation in Shawan sag of Junggar basin as an example, based on the core description, the rock and ore identification, porosity, permeability, major elements of secondary minerals and stable carbon and oxygen isotopes of calcite have been systematically carried out. The results show that under the background of strong oil and gas filling, turbidite and calcite cements are developed, and the two, as well as some debris and feldspar, are corroded, and the reservoir physical properties are relatively good. Turbidite and calcite cements are more widely developed in the background of weak oil and gas filling (water layer and dry layer), but they are basically not corroded, and the reservoir physical properties are relatively poor. This differential dissolution supports the reconstruction of deep clastic rock reservoir by acidic hydrocarbon fluid. Mineral assemblages and hydrocarbon filling history show that turbidite and a small amount of calcite were precipitated at the early stage of diagenesis, and the former was altered by volcanic material in rock debris. The first stage of oil and gas filling took place in the Middle Jurassic when the primary porosity was close to disappearing due to the continuous compaction of the reservoir; Oil and gas filling inhibits the precipitation of turbidite and promotes its dissolution, resulting in secondary pores. The second stage of oil and gas filling in the Early Cretaceous further led to the dissolution of more widespread turbidite and calcite, resulting in a large number of secondary pores. The associated turbidite dissolves and precipitates secondary quartz, kaolinite and late calcite. Late calcite is rich in Mn (>2.5%) and $\delta^{13}C$ negative deviation (-19.5‰ ~ -14.3‰ VPDB). This study confirmed the transformation of oil and gas bearing fluid to the reservoir, indicating that the quality of deep clastic rock reservoir in oil and gas bearing basin can be improved under the condition of sufficient oil and gas sources.

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Special Session 5.2. New advances in lacustrine sedimentology

Oral presentation

Sedimentological response of Late Triassic Carnian Pluvial Episode (CPE) in lacustrine basin: a case study from Yanchang Formation of Ordos Basin

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The Carnian Pluvial Episode (CPE) is one of the most significant climate abrupt events on Earth in the Triassic, and the abrupt climate environment has an important control effect on the sediment characteristics of inland lake basins.In this paper, the most important petroliferous basin on land in my country: the Triassic Yanchang Formation in the Ordos Basin is taken as an example. Based on the latest research progress on global paleoclimate, event sedimentation, source rock development mechanism and heterogeneous integration surface in terrestrial basins, and through rethinking and researching some sedimentation and accumulation problems of the Yanchang Formation, the following three points of understanding have been obtained: (1) The Carnian period of the Middle–Upper Triassic Yanchang Formation in the basin has been redefined, and the sedimentary response to the CPE of the Yanchang Formation has been clarified. The top boundary is equivalent to the stratigraphic boundary between the Chang 4+5 member and the Chang 3 member, and the CPE roughly corresponds to the deposition of the "Chang 7 member black shale event"; (2) During the Carnian and CPE, the Yanchang Formation sedimentary lake basin showed the characteristics of "rapid lacustrine transgression and oscillating slow retreat", which is very conducive to the development of high-quality source rocks; (3) Affected by the paleo-climate and CPE in the Carnian period, the Yanchang Formation developed two upper and lower xenoconformity formed due to abrupt climate and environment, and they both had a significant control effect on the distribution of oil and gas. This research is of positive significance for in-depth discussion of the formation and evolution mechanism of Yanchang Formation lake basin, sedimentary sequence filling and evolution characteristics, and guiding the practice of oil and gas exploration.

Theme 5. Continental clastic depositional systems

Special Session 5.2. New advances in lacustrine sedimentology

Oral presentation

Identification and quantitative characterization of silty laminae and beds in lacustrine organic-rich shales

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Influenced by sedimentary environments such as sediment provenance, paleoclimate. and paleoproductivity, various laminae and beds are developed in the lacustrine organic-rich shales. Silty laminae and beds developed in the shale formation in the freshwater lake basin are important reservoir spaces and efficient channels for oil and gas migration. In addition, the identification and characterization of silty laminae and beds are critical to sedimentary environment analysis, formation evaluation, and sweet spot optimization. Researchers carried out many studies on the drilled rock samples containing silty laminae and beds, including core description, mineral composition analysis, scanning electron microscope, particle size, nitrogen adsorption and other experimental methods. However, drilled rock samples are limited and expensive; it is challenging to realize the fine evaluation of heterogeneous organic-rich shale formations. Chang 7 member organic-rich shale formation in the Ordos basin is studied in this research. We used conventional logging and electric imaging logging to realize the identification and quantitative characterization of silty laminae and beds in lacustrine organic-rich shales. It mainly includes the following three steps: (1) Lithology identification: the logging response in the organic-rich shale formation are analyzed. The criterion of lithology identification is established, and it can be clear that the silty laminae and beds with thicknesses greater than 1cm can be identified by the electric imaging logging. (2) Identification of silty beds: the essence of silty beds identification based on the electric imaging logging is edge detection. A new method based on image processing and morphology is established. The silty laminae and beds with thicknesses greater than 1cm can be identified. (3) Quantitative characterization of silty laminae and beds: based on identifying organic-rich shales and silty beds, the thicknesses of silty beds are counted. The distribution of the thickness of silty beds can be characterized by fractals. This new method can be used in uncored wells to identify and quantify silty laminae and beds. Moreover, the results are critical in the sedimentary environment analysis, formation evaluation and sweet spot optimization.

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Special Session 5.2. New advances in lacustrine sedimentology

Oral presentation

Recognition of Milankovitch cycles in the Early Triassic in the Junggar Basin, NW China; implications for sequence stratigraphy

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Milankovitch cycles affected paleoclimate changes, and thus the distribution of different facies in sedimentary basins. The effects of astronomical forcing have been recorded as astronomical frequency signals in sedimentary sequences through geological history, the Milankovitch cycles has the isochronal characteristics in the time domain and is an effective way to realize the division and comparison of the high frequency deposition cycles. Based on the theory of Milankovitch and taking the Early Triassic strata in the central depression, Junggar Basin, as the research object, using natural gamma log and resistivity log data, through frequency spectrum analysis, Milankovitch signal identification and period division were performed on the target layer in the study area. The filter curves of the short eccentricity period 99.0 ka and the short slope period of 40.5 ka extracted by the logging curve are taking as the reference curves of the fifth-order sequence deposition cycle and sixth-order sequence deposition cycle, and the high frequency sedimentary cycle correlation framework of the Early Triassic strata in the central depression, Junggar Basin, was established. The results show that the complete Milankovitch deposition cycle is maintained in the central depression, Junggar Basin, and the cycles are mainly controlled by eccentricity period (99 ka) and slope period (40.5 ka). Using the ratio of the total thickness of the Early Triassic to the thickness of the dominant cycle, it is estimated that there are about 15 short-term sequences and 40 ultra-short-term sequences, the thickness of the strata caused by eccentricity period and slope period is 6.21–7.35 m and 2.25–2.89 m, the average deposition rate is 6.53 cm/ka. In the paper, a new method is proposed for logging identification and division of high frequency stratigraphy, which provides a reference for sequence stratigraphic division.

Theme 5. Continental clastic depositional systems

Special Session 5.2. New advances in lacustrine sedimentology

Oral presentation

Seismic response characteristics of typical sublacustrine landslides in continental basins of China

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Sublacustrine landslide is a kind of deep-water sedimentary system formed by the action of gravity, which plays an important role in the global continental basin sedimentary system. This kind of landslides can not only form conventional clastic reservoirs in the center of the lake basin, but also facilitate the formation of fractured oil and gas reservoirs in deep layers due to the development of a large number of non-tectonic cracks. Based on the seismic data of songliao, Jiuquan and Junggar basins, a large number of subaqueous landslides have been identified. The subaqueous landslide in continental lacustrine basin has obvious landslide shape and sedimentary structure, which is characterized by hillock shape, transparent and irregular reflection characteristics on the earthquake. The extensional pear-type fault is developed at the head area, thrust structure and small folds can be seen at the landslide toe, and concentric circular pressure ridge generally exists on the plane. There are various types of landslides in continental basins by lithology, including muddy landslide, sandy landslide and gravelly landslide. According to the morphology, it can be divided into emerged landslide and restricted landslide. The results are of great scientific significance for the exploration of continental basins in China.

Theme 5. Continental clastic depositional systems

Special Session 5.2. New advances in lacustrine sedimentology

Oral presentation

Sequence stratigraphy in supply-dominated, hydrologically closed lakes

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Long-lived lakes comprise an underestimated portion of the rock record. They commonly form when the extension of continental areas is initiated. Later these lakes transit into marine systems of the rift basins. Finally, shelves evolve, where the concept of „classic" marine sequence stratigraphy of post-rift successions is rooted. The strong structural overprint necessarily led to special rift sequence stratigraphy and/or recognition of tectonic successions. This latter is applicable in compressional areas, e.g. in marine foredeep of orogenic belts. These finally get into an overfilled stage, when extensive lakes form. Despite the basic differences sequence stratigraphy of lakes is still not well understood.

In marine systems accommodation determined by eustacy and subsidence is not influenced by sedimentation. In lakes, eustacy cannot simply be replaced by climate-driven lake level (LL). LL sensitively reflects climate changes only if the lake has no outflow, or LL is below the spill point. Stratigraphic forward modelling simulating long-term LL changes in hydrologically-closed lakes with high sediment supply highlighted an extremely specific feature: LL rise induced by the normal regression of the shoreline. If a coastal prism develops by progradation of deltas or shelf-slope clinothems, the system adjusts by LL rise, as these lakes maintain a steady, equilibrium surface area, due to rapid response to climate. This produces accommodation to fill, so aggradation (and progradation) continues with positive feedback until the sill height of the spill point is reached. Therefore, unlike seas, development of accommodation in lakes is not independent of sedimentation.

Modelling, seismic, field and well data show that the regression-induced component of lake-level rise is able to compensate for the climatically-induced falls, therefore an overall steady and rising LL pattern develops. The sedimentary architecture of clinoforms is interpreted as TST, early and late HST, without well-developed FSST or LST. These geometries and processes are demonstrated by the seismic scale clinoforms from the Late Miocene Lake Pannon, Hungary, where slope progradation and normal regression lasted for about 6 Ma. Other Miocene and Triassic examples are also shown.

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Special Session 5.2. New advances in lacustrine sedimentology

Oral presentation

Extraordinary intraclast conglomerates in a stormy, hot-house lake: Early Triassic, North China Basin

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Large lakes frequently record storm activity with the evidence including the presence of swaley and hummocky cross stratified sandstones. Such facies are found in the North China Basin in the Early Triassic, a setting that records a mix of fluvial and lacustrine environments. In addition to typical storm-generated sandstones, there are also conglomerates that record events of exceptional strength that were capable of generating clasts from lithified lake-beds. Cementation of fine to medium gained sands was by a range carbonate cements (microspar, radial, prismatic cement, and poikilotopic coarse spar), with erosion producing flat-pebble conglomerates and angular clasts up to 30 cm in size. However, the most unusual clasts are concentrically-laminated concretions that resemble oncoids. These record multiple phases of burial, growth, erosion, reburial, further cementation and growth etc. that resulted in a diverse range of "oncoids" that can record up to seven episodes of formation. The intraclast conglomerate beds record events that began with an erosive phase of lake bed break-up, followed by a (probably brief) transportation phase and finally a reorientation of flat clasts into fan-like arrangements at bed tops. The super-greenhouse conditions of the Early Triassic likely favoured the rapid cementation within the North China whilst such conditions may also have triggered frequent, powerful hurricanes in this low palaeolatitude region. Modern hurricanes are capable of major erosion but only modest sediment transport with the result that they remobilise and redeposit local sediment as seen in North China.

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Special Session 5.2. New advances in lacustrine sedimentology

Oral presentation

Discovery and petroleum geological significance of beach sand in Badaowan Formation, Shawan Sag, Junggar Basin

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In the context of comprehensively promoting efficient exploration, it is particularly important to find shallow high-quality reservoirs. Beach sand generally has high compositional maturity and textural maturity, and good reservoir physical properties. It is one of the important reservoir types in the terrestrial basin of China. However, due to the thin thickness of the reservoir, it is difficult to identify and characterize the sand body and predict the distribution. Based on core, logging, analytical test, and 3D seismic data, this paper systematically studies the sedimentary characteristics and distribution of the beach sand of the Badaowan Formation in Shawan Sag, Junggar Basin. The beach sand of the Badaowan Formation is composed of the beach ridge and the beach trough. The beach ridge is mainly composed of sandy conglomerate, pebbled sandstone, and sandstone, and the sedimentary structure is mainly composed of massive bedding, wave cross-bedding, and soft deformable bedding. The beach sand is vertically formed by the superposition of multi-period beach sand. The single-stage beach sand is generally composed of 3 sedimentary sequences, with pebbled sandstone at the bottom, a sandy conglomerate in the middle, and sandstone at the top. The beach trough has a low content of sand and is mainly composed of thin siltstone, and the sedimentary structure is mainly composed of a reverse grain sequence in the vertical direction. The detrital materials of the lakeshore are moved and deposited perpendicular to the lakeshore under the action of waves, forming a striped distribution of the beach ridge. The seismic section shows the reflection characteristics of strong amplitude lenticular discontinuity. The stratal slice shows that the shape of the beach sand is clear, distributed in rows and belts, and the scale is large. The newly discovered beach sand at the bottom of the Badaowan Formatio

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Poster presentation

The genesis and influences on oil-bearing property of thin sandstones interbedded in deep lacustrine shales

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Shengbei area is located in the northern part of Dongying Sag, Bohai Bay Basin, eastern China. At present, industrial oil flow has been found in the shale of the upper part of the fourth member of the Paleogene Shahejie Formation. These shale belonging to the deep lake subfacies generally develop thin sandstone lawyers interbedded with different thicknesses. The genesis of these thin sandstone lawyers and their influence on the oil content of shale are not clear. In this paper, we used the method of core observation to find that the bottom of the sand body is mostly developed with load structure. When the thin sandstone lawyers is thick, it is mostly developed with fining-upward graded bedding. Therefore, the thin sandstone lawyers interbedded in the deep lake subfacies shale in the study area are formed by gravity flow deposition. Based on the comprehensive study of core analysis and logging data, it is considered that the provenance of these thin sandstone lawyers mainly came from Chenjiazhuang uplift in the north. In the upper part of the fourth member of Shahejie Formation in the study area, the climate was gradually dry, the lake water was gradually shallow, the gravity flow sediments were easier to reach deep lakes, and thin sandstone lawyers interbedded in shale were formed around the end of gravity flow. By using geochemical analysis method to analyze the oil-bearing property of shale with thin sandstones interbedded, it is found that with the increase of thin sandstones interbedded, the oil-bearing property of the whole shale gradually decreases, which is contrary to the conventional understanding of oil-bearing property. This paper gives a reasonable explanation. The excessive development of gravity flow has a dilution effect on the enrichment of organic matter, which leads to the decrease of organic matter abundance and the deterioration of overall oil content. n in Shawan sag is a new area for efficient shallow exploration and has great petroleum geological significance.

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Special Session 5.2. New advances in lacustrine sedimentology

Poster presentation

Sedimentary evidence for hydrothermal activity in cores from lake basins of the East African Rift System

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To better understand the magnitude and potential impact of hydrothermal activity on Pliocene lakes in the East African Rift System, we examined sedimentary evidence from core material collected from two basins. Sedimentary dykes, filled with brecciated and injected sedimentary material, are abundant in the long drill cores through Pliocene lake-basin successions from the Northern Awash Basin in Afar, Ethiopia and the Baringo Basin, Kenya. These features are accompanied by cemented and altered zones, as well as fracture networks filled with injected slurry material, and/or staining of adjacent host sediments. Fractures and injectites typically contain authigenic mineralized zones and are mainly filled with remobilized sand and/or brecciated mudstones, often with internal bedding, as well as laminated or bedded clay. Multiple cross-cutting phases are apparent, and in some cases, evidence indicates that the timing is roughly syn-sedimentary, determined to be within the corresponding depositional cycle of lake-level rise-and-fall. Thick (~1–2 m) zones of horizontal or obliquely oriented beds of interbedded host sediments with brecciated and injected material, including injected crystalline material, are particularly common in diatomaceous deeper-lake deposits, which may indicate increased activity in the hydrothermal systems during wetter periods or rheological control on the position of these thicker horizontal injectites. Supporting evidence for high-temperature, pressurized fluids moving through the shallow subsurface, and potentially directly influencing the Pliocene lakes, include brecciation, resetting of zircons, anomalous geochemical signatures (from scanning X-ray fluorescence), and crystalline injected material. The recognition of these features in geothermally active rift basins, such as in the East African Rift System, impacts our understanding of: (1) zircon geochronology; (2) the depositional environments and hydrochemistry of lake systems; and (3) the influence of climate on lake cycles, both through overthickened packages that affect age-models and time-series results, as well as possibly through cyclical fluctuations in the activity of hydrothermal systems in lake and lake-margin environments.

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General Session

Oral presentation

European loess – similarities and differences revealed by SEM analysis of grain surface microtextures

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Loess is a type of terrestrial, clastic sediment formed by the accumulation of wind-blown dust and composed dominantly of silt-sized particles. It is usually inter-bedded with soil horizons forming loess–palaeosol successions (LPS), which provide a detailed archive of palaeoclimate and palaeoecological changes. In order to determine differences of loess deposits across Europe, we analyzed grain surface microtextures from six different loess locations in four countries: Pegwell Bay (UK), Brattforsheden and Bonäsheden (SWE), Zmajevac and Branjina (CRO) and Leninsk (RUS).

Quartz grains from loess deposits were analysed with scanning electron microscopy (SEM) in magnification range of 20–3500x. Grain-size distributions in the loess samples point to dominance of silt-sized particles, with the exception of samples from Leninsk, where sand fraction is more dominant. Samples from all localities show the dominance of angular to very angular grains (70–80%) and a smaller percentage of sub-rounded and rounded grains. Conchoidal fractures are the dominant surface features in samples from all localities (approx. 40% of all grains), followed by subparallel linear fractures, parallel and/or radial steps, grooves, linear/parallel striations and V-shaped percussion marks. Analysis of grain shape, angularity, relief and surface microtextures points to the glacial origin of the material from all localities, as well as a complex transport history, which in the final aeolian phase was of a proximal character. SEM coupled with other analysis (U–Pb provenance, grain-size, mineralogy, etc.) points to glaciofluvial systems that drained the retreating Fennoscandian Ice Sheet as the likely source for the loess material in Swedish localities. In Leninsk, Ural Mountain glacial sediments and proglacial outwash deposits of the Fennoscandian Ice Sheet were the source material which was subsequently transported to the south via the Volga River. In the UK, British–Irish and Fennoscandian Ice Sheet derived glaciofluvial sediments were the source of loess at Pegwell Bay, while sediments derived from Continental Europe possibly also contributed. Loess from Croatian localities is sourced locally from Slavonian Mts. derived material and from the Danube flood plain, where sediment produced in the Alps was transported via Danube river.

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General Session

Oral presentation

Accumulation vs non-accumulation in a distributive fluvial system: what do fluvial–aeolian deposits reveal about cyclicity?

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The occurrence of fluvial–aeolian interactions has been reported both in ancient and recent sedimentary records. These interactions can be driven by allogenic and autogenic processes, manifesting several fluvial–aeolian interaction styles. Although previous works have shown many examples of fluvial–aeolian interactions and their depositional controlling factors, few have described the significance of these interactions within a Distributive Fluvial System (DFS) dynamic. Especially regarding the relationship of aeolian sedimentation associated with non-depositional indicators such as paleosols. Thus, this study aims to classify fluvial–aeolian interactions and the relationship between aeolian deposits and paleosols. Seeking a meaning for what causes the system to be prone to accumulation or not depending on the activity of the DFS. The classification scheme is demonstrated through reference examples from the Late Permian Rio do Rasto Formation (Morro Pelado Member), Paraná Basin, Southern Brazil. To accomplish this, 15 sedimentary logs were surveyed, comprising three boreholes (794.41 m) and 12 outcrops (176.04 m). In addition, six lateral panels were interpreted for architectural analysis, and six thin sections were examined to demonstrate fluvial–aeolian reworking. At the moment, 28 lithofacies and 15 architectural elements (four aeolian and 11 fluvial-related) were recognized. Four main fluvial–aeolian interaction anatomies were identified: (i) Water-table controlled interaction; (ii) Fluvial reworked aeolian deposits; (iii) Aeolian reworked fluvial deposits; (iv) Fluvial breaching of dunes and their reworking by catastrophic floodings. Fluvial–aeolian interactions occur on an autocyclic scale whereas paleosol's relationship with aeolian processes is yet to be determined.

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General Session

Oral presentation

Interdune deposition in Precambrian aeolian systems: architecture, depositional model and controlling factors (Galho do Miguel Formation, SE Brazil)

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Studies of Precambrian aeolian successions have demonstrated that the processes involved in dry and wet interdune sedimentation were potentially different from their Phanerozoic counterparts. These differences were the result of the unique paleoenvironmental conditions that operated throughout the Proterozoic, influencing the nature of sedimentary processes. To clarify this aspect, the Mesoproterozoic Galho do Miguel Formation was studied using architectural-element analysis. The aeolian succession comprises deposits of dunes (simple and compound) and dry and wet interdunes. The organisation of the architectural-element types indicates two sub-environments of a hybrid dry–wet aeolian system. Dry and wet aeolian sub-environments were coeval and time-varying, likely controlled by the interaction between local topographic relief and the water-table level. In dry sub-environment, the water table did not influence the construction of climbing dunes and dry interdunes, but this was essential for long-term aeolian accumulation. Due to the proximity of the water table to the depositional surface, the dry interdune flats were eroded only up to the groundwater level, where the wetness inhibited sand removal by the next migrating dune. This condition allowed the accumulation of thick beds of dry interdune deposits (up to 3 m thick). In the wet sub-environment, the progressive rise of the groundwater and the amalgamation of interdune deposits produced thick wet-interdune stratal packages (up to 8 m thick). The accumulation of thick packages of interdune strata in both sub-environments was generated by high rates of vertical accumulation of the interdune substrate and progressive relative rise of the water table. These conditions enabled the long-term accumulation of Precambrian aeolian systems, in which the stabilising effects of vegetation did not operate. In conclusion, the aeolian architecture of the Galho do Miguel Formation suggests that Precambrian aeolian systems probably produced thicker dry and wet interdune strata than Phanerozoic examples, and hybrid dry–wet aeolian systems provided the best conditions for aeolian accumulation and preservation.

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General Session

Oral presentation

Scales of fluvial and floodplain deposition within alluvial stratigraphy (Willwood Formation, Wyoming, U.S.A.)

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Deposition within alluvial systems occurs within two major settings, the channel and floodplain. Lithofacies patterns within each setting document the character of sediment transport, paleo-topography, and environmental conditions. Yet these are often interpreted in isolation from one another. This study compares the vertical scales of depositional packages within channel and floodplain strata with the aim of clarifying sediment partitioning and paleo-topography between them. Data were obtained from the early Paleogene Willwood Formation that crops out in the Bighorn Basin of Wyoming, U.S.A. The data include measurements of the relief on bar clinoforms (n = 112), fluvial story heights (n = 60), mud plug thickness (n = 13), single-storied splay channels (n = 50), and multi-storied fluvial sandbodies (n = 102) as well as new and compiled data on overbank paleosol cycle thicknesses (n = 45). The data were decompacted based on estimated burial depths to achieve more accurate assessments of thickness. Story heights and mud plug thicknesses display statistically indistinguishable means (4.7 m and 5.5 m) and medians (4.2 m and 5.8 m). These estimates are higher than bar clinoform relief mean and median values (1.5 m and 1.3 m). However, the largest bar clinoforms do achieve thicknesses similar to story heights and mud plug thicknesses. These observations mirror recent results from modern river systems suggesting bar clinoforms typically only capture ~0.3 of the true flow depth. Multi-storied sandbodies and overbank cycles in the Willwood Formation display statistically indistinguishable means (10.8 m and 9. 2 m) and medians (9.3 m and 9.1 m) from one another as well. This study infers that story heights and mud plugs provide more robust estimates of paleo-flow depths from alluvial strata, which likely correspond to channel-reach means. The similarity in overbank cycle and multi-storied sandbody thicknesses suggest compensational depositional processes that acted to fill floodplain topography. Lateral tracing of coeval strata suggests this occurred during major avulsions post-dating aggradation of the channel by one flow depth above the floodplain. Based on previous studies and constraints on allogenic forcings, this is interpreted to be a meso-scale, autogenic behavior.

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General Session

Oral presentation

Evolution of the depositional environment of The Roseneath–Epsilon–Murteree (REM) strata in the Cooper Basin, Australia: a multidisciplinary revisit with new data

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The Early to Middle Permian Roseneath–Epsilon–Murteree (REM) strata of the Cooper Basin in Australia host substantial conventional and unconventional resources, and are believed to be the most feasible shale gas play in Australia. Despite their potential resource significances, the REM strata are poorly understood with regard to regional facies architecture and paleogeographic evolution. Using a multidisciplinary approach with robust data (facies analysis, petrology, wireline logs, and geochemistry), the sedimentary evolution of the REM strata is described within a new sequence stratigraphic framework defined by key surfaces identified from cores and wireline logs. Detailed facies analysis of over 1400 m of cores and wireline logs from nine wells identified twelve lithofacies and eight facies associations for the first time which reveal various depositional processes and environments. The REM strata are interpreted as a fluvial–deltaic–lacustrine system with glacial influences. 1^{st}-order and 2^{nd}-order Maximum Flooding Surfaces (MFS) define a regional sequence stratigraphic framework which subdivides the REM strata into four sequence units, among which two Transgressive–Regressive (T–R) cycles can be observed. Paleogeographic maps of four depositional phases suggest that the REM strata were dominated by a lacustrine system with some delta and mire deposits. Rivers primarily drained from the Gidgealpa, Merrimelia, Packsaddle and Innamincka ridges (GMI Trend) in the north or northeast as indicated by sandstone percentage and gross unit isopach maps. Possible marine incursions into the lake probably came from the east when eustatic sea level was high. Far field effects from thermal subsidence of Eastern Australia and paleoclimate (glaciation, interglaciation) primarily controlled deposition of the REM strata. A similar multidisciplinary approach should help elucidate the evolution of other fluvial–deltaic–lacustrine systems in other basins and aid in resource prediction.

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General Session

Oral presentation

End-Permian paleoenvironmental changes in Parana Basin, Western Gondwana

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The last stages of the Permian period sedimentary record provide relevant clues for understanding global atmospheric and biological changes that led to the largest known mass extinction event. The Rio do Rasto Formation records this critical interval within the Paraná Basin, southeastern South America, and raises the discussion relative to the very complex stratigraphic framework and variable hierarchies of sedimentary processes related to distributive fluvial systems (DFSs). This field-based study holds sedimentological, stratigraphic, paleontological, and petrographic data, with more than 600 m of logged section surveyed in 40 outcrops in South Brazil, besides 1200 m of core described. In this sense, 22 lithofacies were recognized and arranged in 13 facies associations, being part of four subsystems within DFSs: 1) fluvial deposits; 2) low-slope, shallow lakes; 3) terminal splay lobes, and 4) eolian deposits. The overall strata exhibit a progressive process of aridization, and the paleocurrent pattern reveals an endorheic drainage basin, where the Norte Basin, in Uruguay, and the Huab Basin, in Namibia, would also be part of a low-relief, depression area within Gondwana. This process is well-recorded through a change from shallow lacustrine environments affected by storm events to a high-variability discharge setting, where perennial channels and lakes were replaced by small lakes, ephemeral streams, and extensive floodplain areas, with the development of paleosols and eolian sand sheets. However, this process was not abrupt, and this study reveals a cyclic pattern, in which aqueous flows are deposited and exposed to subaerial conditions, at different frequencies and depositional settings. The fossil content of a portion of the Rio do Rasto Formation strata indicates a progressive loss in biological diversity to the end-Permian, in particular to the non-marine bivalves, conchostracans, tetrapods, and plants, due to an increase in the input of freshwater and sediment, revealing import changes in discharge variability, sedimentation rates, and aridity. This study brings a data collection that reveals the architectural complexity within DFSs, when Western Gondwana underwent a progressive aridization and climate change, affecting directly the biota and depositional processes.

Theme 5. Continental clastic depositional systems

General Session

Oral presentation

Archean continental sedimentation: the Singhbhum perspective

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Terrestrial sedimentary successions provide unambiguous evidence of subaerial exposure of continents. High resolution sedimentological analysis coupled with robust geochronological data are essential to constrain the timing of continental emergence on early Earth. The Singhbhum Craton of India preserves an extensive Archean terrestrial volcano-sedimentary record. Recent surge of geochronological data from the Archean sedimentary successions of the Singhbhum Craton provide us an opportunity to infer early Earth surface processes and crust–mantle interactions. The Paleoarchean (3.5–3.2 billion years) Iron Ore Group of rocks in the western and eastern belts bear alluvial fan–fluvial facies associations and indicate continental emergence in the earlier part of the Earth history. The banded iron formations and associated clastics of the Iron Ore Group of rocks indicate largely shallow marine to shelfal sedimentation. The extensive Mesoarchean sedimentary record (the Bisrampur and the Dhanjori formations in the northwestern and northern part of the Craton) implies continuation of terrestrial sedimentation because of subsequent relative sea level fall. Rise of relative sea level around 3.0 billion years is inferred from the shallow marine sedimentary facies associations of the Simlipal Group in the east and the Birtola Formation of the Darjing Group in the west. A ~2.8 billion years extensive felsic magmatic record is well preserved in the Singhbhum Craton. No supracrustal rocks around 2.5 billion years are preserved on the Singhbhum Craton, although Neoarchean (2.8–2.5 Ga) detrital zircons are reported from the Paleoproterozoic metasedimentary rocks of the Craton. Published sedimentological and geochronological data suggests non-deposition and/or erosion on the Singhbhum Craton and thus development of a prolonged unconformity along the northern margin of the Singhbhum Craton throughout the Neoarchean.

Theme 5. Continental clastic depositional systems

General Session

Oral presentation

A sedimentological perspective on the taphonomy of large dinosaurs

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The often outsized proportions of dinosaurs may have made it difficult to get buried on Mesozoic landscapes via typical modes of sedimentation, particularly in the case of large bones and intact carcasses. However, a review of taphonomic literature reveals that there is more than one way to bury a dinosaur in sedimentary deposits. The living can forcefully install bone into the subsurface via trampling, provided the sedimentary substrate is malleable and receptive to loading. However, large dinosaur bones, especially those with high surface area to volume ratios, would be inordinately difficult to trample underground in a reasonably intact state. Another way to introduce a dinosaur to the subterranean sedimentary realm is via miring. Several studies have concluded that death and burial of dinosaurs resulted from entrapment and subsequent encasement in viscous sediment. Dinosaur remains are also often entombed in deposits of ancient channels, and were likely buried by some combination of downstream, lateral, and vertical accretion. Dinosaur fossils embedded in ancient floodplain deposits were presumably buried by bedload or suspension load sedimentation during overbank flood events. However, the average thickness of sedimentation units deposited on modern floodplains, even during major floods, is typically inadequate to bury a large dinosaur limb bone, vertebra, or skull, let alone an entire carcass, which could easily extend a meter or more above ground surface. Thus, it seems necessary to invoke sedimentation events of unusual magnitude, or aggradation events focused in low areas such as abandoned channel segments, in order to effectively bury a large dinosaur carcass. Sediment-rich surface flows, such as sandslides and debris flows, are being diagnosed as mechanisms of dinosaur burial with increasing frequency. This trend makes good taphonomic sense, because the sediment-charged nature of mass flows results in substantially thicker deposits than those typical of more dilute sedimentation events. The abundant dinosaur bonebeds of the Upper Cretaceous Maevarano Formation of Madagascar provide an example of exceptional burial events yielding a spectacular fossil record. In this unit, deposits of recurrent fine-grained debris flows preserve an extraordinary snapshot of a Late Cretaceous ecosystem.

Theme 5. Continental clastic depositional systems

General Session

Oral presentation

Quantitative prediction of sand bodies in a sparsely explored zone of the Tarim Basin: a case study of the Aketao Area

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Thin sandstone reservoirs of the fan delta front sub-facies occur in the early Neogene (Miocene) series of the Aketao (Akto) structural belt within the Kunlun piedmont zone of the Tarim Basin. Oil and gas reservoirs in this area correspond to stratigraphic traps. However, owing to the low density of the 2D seismic survey grid deployed in the Aketao belt, inferior seismic data quality, and lack of well logging data, reservoir prediction in this area suffers from a multiplicity of problems and it is difficult to effectively identify sand bodies. Here, a new research approach is proposed involving the use of 3D seismic, well logging, and drilling data from a neighboring highly-explored 3D seismic survey area as a reference for the 2D seismic interpretation of the non-drilled Aketao survey area. Moreover, this approach is integrated with forward modeling and the inversion of post-stack seismic data to identify sand bodies. A comparison of the seismic reflection characteristics clarifies that these 3D and 2D seismic survey areas share similar sedimentary environments. Forward modeling confirms their similar reservoir characteristics, while the reservoir distribution in the 2D seismic survey area is effectively mapped via the inversion. The results show that for a 2D seismic survey area characterized by a low degree of hydrocarbon exploration and appraisal, and a lack of well logging data, the proposed approach can confirm the sedimentary characteristics that correspond to the seismic reflection characteristics, and can quantitatively map the reservoir thickness.

Theme 5. Continental clastic depositional systems

General Session

Poster presentation

Why are complex aeolian systems apparently scarce in the Precambrian record? Lessons from the Galho do Miguel Formation (SE Brazil)

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Despite the favourable palaeoenvironmental conditions for the widespread construction of complex aeolian systems over the Precambrian, the depositional architecture of these deposits is commonly associated with simple dunes or sand sheets systems. Based on this paradigm, the question raised is: why are complex aeolian systems apparently scarce in the Precambrian record despite favourable conditions? To address this issue, this study examined the Mesoproterozoic Galho do Miguel Formation (Serra do Espinhaço, SE Brazil). The facies analysis allowed the identification of four main architectural elements: simple and compound cross-bedded sets (simple dunes and draas), planar-parallel sandstone strata (dry interdune), and wavy and planar-parallel bedded sandstone (sand sheets). The architectural complexity and the relationships between these element-types suggest the development of a large aeolian system composed of varied bedforms morphologies and scales. The stratigraphic organisation and the presence of wide, irregular, and erosional surfaces through the aeolian succession can represent periods of different sedimentary pulses, which appear to be associated with different conditions of aeolian accumulation and sand availability. The existence of damp/wet sedimentary structures close to plinth dunes indicates that the water table was seasonally near the dune slipfaces. During periods of high groundwater level, the availability of wind-blown sand hampered the construction of large aeolian dunes. However, the progressive water-table rise provided accumulation space that allowed long-term sand accumulation and system preservation. Thereby, it is admitted that water-table variations played an important control over the wind sand-saturation and the aeolian accumulation, producing successive periods of erg construction, accumulation, and destruction. Thus, two inferences are possible. First, Proterozoic aeolian succession were vulnerable to erosion due to the absence of sand-fixing agents. Thus, the deposits were temporally accumulated and progressively eroded over time. Second, it is possible that complex aeolian systems were common in Precambrian landmasses, as present-day Mars's surface, but in dry environments their potential for accumulation and preservation was low.

Theme 5. Continental clastic depositional systems

General Session

Poster presentation

Extracting the fingerprint of a city's history: the anthropogenic impact of Vienna as seen in downstream Danube river sediments

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The Anthropocene, a still pending potential new unit of the Geological Time Scale, describes the intensified anthropogenic influence on the environment and geological processes and its traces in geological archives. While the rapid rise of human impact on the Earth System has been investigated on a global scale, regional studies characterizing this growth are scarce, especially for urban or peri-urban environments.

In this project, we investigate the anthropogenic impact of the metropolis Vienna on its peri-urban environment and the proposed beginning of the Anthropocene epoch in the 1950s CE by applying sedimentological and geochemical methods. Previous studies (Wagreich et al., 2022) have successfully detected the human influence in urban sedimentary archives of Vienna (coarse sediments) using artificial isotopes and anthropogenic trace metals. For our project, we extend the study area from Vienna to the city of Hainburg to investigate Vienna's impact in both anthropogenic and natural sediments downstream the Danube river. In this area, direct human intervention in the environment is highly variable, from locally strong (e.g., hydro-power dams, airport constructions), to non-existing (National Park Donau-Auen), thus offering a suitable location to trace and quantify the extent of anthropogenic impact.

Within petrographic facies, sedimentological and geochemical markers are applied to characterize the anthropogenic strata in this area: The archive of fine-grained natural Danube deposits, i.e. erosional profiles and sediment cores, is analysed for trace metals, artificial radiogenic isotopes, and (micro-)plastics with the aim (i) to characterize the anthropogenic fingerprint of Vienna in the sediment in space and time, starting from today and going back to its Roman foundation in the 1st century CE, (ii) to identify and evaluate the proposed Anthropocene geological boundary around 1950 CE, and (iii) to evaluate a potential correlative stratigraphic reference section/point for the Anthropocene downstream of Vienna.

Reference

Wagreich, M., Meszar, M., Lappé, K., et al. (2022). The urban sediments of Karlsplatz, Vienna (Austria) as a candidate Auxiliary Boundary Stratotype Section and Point for the Anthropocene series. Anthr. Rev. 205301962211364. https://doi.org/10.1177/20530196221136427.

Theme 5. Continental clastic depositional systems

General Session

Poster presentation

Late Cretaceous fluvial systems of the Gippsland Basin, SE Australia

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Upper coastal plain deposits of the Gippsland Basin have remined a mystery due to poor imaging on seismic data. Well log data through the Late Cretaceous interval reveals a fine-grained floodplain characterized by mudstones, siltstones and thin coals, intersected by numerous discontinuous channel sands. This alluvial plain transitions seaward into a back-barrier zone characterised by large ombrogenous peat domes and meandering tidal channels, which in turn transition to large, sandy barriers. The lower coastal plain is well imaged on seismic data due to the large acoustic impedance contrast between coals and siliciclastics. However, the upper coastal plain lithologies have similar acoustic impedance properties, hence result in discontinuous, low amplitude seismic reflectors. As a result of this poor seismic imaging, the upper coastal plain has not been well documented. Core and well data through the Late Cretaceous alluvial plain deposits reveals a range of lithofacies which comprise the channel and overbank depositional environments. Individual fluvial sands are approximately 1–2 meters thick, however are often amalgamated, consist of well sorted fine–medium sandstone, and commonly display trough cross bedding. Overbank deposits consist of floodplain mudstones and siltstones, which are up to 3 m thick in core and up to 30 m in well logs and include thin carbonaceous shales, and thin crevasse sandstones. The transition from the alluvial plain to the back barrier environment occurs approximately 40 km from the paleoshoreline, and is evident by a thickening and amalgamation of coals, and increasing dinoflagellate prevalence in associated clastic sediments. Tidal influence may extend as far inland as approximately 35 km from the paleoshoreline.

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General Session

Poster presentation

Factors controlling the sedimentary evolution in an Upper Jurassic fluvial system (Morrison Fm, Colorado Plateau)

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The terrestrial deposits of the Upper Jurassic Morrison Formation of the Western Interior USA (Colorado Plateau) are known worldwide for their abundance and diversity of vertebrate fossil remains. Numerous palaeontological studies have been focused on these deposits for decades, but detailed palaeoenvironmental works are still necessary for reconstruction of these ecosystems and their evolution through time, for evaluating biostratigraphic trends. Here, we present a preliminary palaeoenvironmental study based on a detailed sedimentological description of two sections of the Morrison Fm in the Bighorn Basin (north-central Wyoming), separated by 2 km apart, which are correlated by the recognition of depositional sequences.

The Upper Jurassic Morrison Fm in the studied area is 110 m thick, and mainly represented by marls and mudstones intercalated with tabular to lenticular sandstones bodies, recording deposition in a floodplain and fluvial channels, respectively. The floodplain deposits encompass reddish marls with rhizoliths and calcareous nodules, to grayish-purplish mudstones with occasional nodular gypsum. The fluvial deposits are mostly represented by fine- to medium-grained sandstone bodies deposited in a mixed braided–meandering fluvial system. Crevasse-splay and lacustrine limestone beds are also recognized, as well as carbon layers and large plant fossils, indicating that some areas of the floodplains were extensively vegetated. Six depositional sequences were identified, marked by abrupt facies changes, which represent variations in accommodation space or climate. In general, deposition took place in a semiarid climate, with water-level oscillations in the floodplain area: reddish marls with bioturbation and carbonate precipitation represent episodes of prolonged subaerial exposure, whereas the greyish-purplish mudstones with lacustrine limestones were deposited in higher water-level periods under anoxic conditions. Nodular gypsum precipitated during episodes of increased evaporation. Changes in the fluvial architecture, i.e. from isolated to amalgamated (multi-story sheets) channel belts, could relate to changes in accommodation space, in turn controlled by tectonic pulses that determined the amount of sediment supply.

Theme 5. Continental clastic depositional systems

General Session

Poster presentation

Red or black? Sediment color as a reflection of early diagenetic processes in glaciofluvial sediments

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The color of clastic sediments is usually a secondary feature that develops shortly after material is deposited. Mineral composition of color pigment and structure of color coatings carry information about early diagenetic conditions and processes. The research was carried out in two sandpits of the North Bohemian glacial area. Glaciofluvial sediments were deposited during the maximum advance of Elsterian 1 ice sheet. The seven sections with a length of 2–5 m were sampled in regular 5cm interval for petrophysical (magnetic susceptibility, spectral colorimetry) and geochemical (X-ray fluorescence, ICP-MS/OES) analyses. Samples for microscopic analyses were taken irregularly with respect to color transitions and representative sedimentary facies. The X-ray powder diffraction analysis identified mineral phases in colored coatings. Sedimentation, dominated by crossed-stratified gravely sands, took place in preglacial channel (Grabštejn sandpit) and sandur plain (Dubnice sandpit). The proximity of oscillating glacier front caused intense glaciotectonic deformation in Grabštejn sandpit. Horizons of rhythmically bedded fine-grained sediments indicate a short-term deposition in stagnant water environment. Color changes partly correspond to lithological changes. Rusty brown and dark gray coloration preferentially occur in coarse-grained and poorly sorted facies. However, the color transitions do not always respect stratification, and the ornamental coloration emphasizes glaciotectonic deformation of beds. The beds with rusty brown color are enriched by Fe and goethite predominates over lepidocrocite and magnetite in composition of clasts coatings. Beds colored in gray shades are characterized by increased Mn concentrations and birnessite predominates in clast coatings. Its formation is usually associated with microbial activity in the sediment. This corresponds with the dendritic morphology of colored coatings detected by electron microscope. We suppose that redox conditions in shallow subsurface modulated by sedimentary texture and seasonal microbial activity were the main controlling factor of coloration.

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Theme 5. Continental clastic depositional systems

General Session

Poster presentation

Soft-sediment deformation structures – development in laboratory conditions

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An abrupt geological process may lead to the permanent changes in the structure of any clastic sediments. Reorganization of the grains within sediments and modification of the geometry of sedimentary body often result from the liquefaction process. These phenomenon may stem from different trigger mechanisms, such as: interplate earthquakes, volcanic eruptions, salt tectonics or glacioisostatic relaxation. An increase of the water-pore pressure leads to the destruction of the inter-grain contacts, and further brings about the mobilization of grains. Saturated, highly porous and well-sorted fine-grained sand and coarse-grained mud sediments are thought to be the most prone to liquefaction process. It turns out that the determination of critical conditions of the sediment (e.g. grain size, fluidization and saturation) is crucial when considering the development of specific soft-sediment deformation structures (SSDS). The overall objective of this study was to conduct a laboratory experiment on the liquefaction-induced SSDS under controlled conditions (specific sediment texture and content of water). For this purpose, a special device simulating seismic shocks was used, among others with known magnitude and frequency, and as a consequence, not only qualitative, but also quantitative description and characterization of the liquefaction process was achievable. The experiment has shown that the share of the fine-grained fraction (silt and sand) and water has a significant impact on the development of soft-sediment deformation structures as a result of sediment liquefaction. The finer the sediment fraction, the easier it is to liquefy the sediment, with lower energy of seismic tremors (magnitude 3.4–4). The study confirmed that the clay fraction has a very important influence on the liquefaction of the sediment. Its high content (> 8.5%) hindered the formation of deformation structures. Injection structures (flame and dyke structures) were mainly created from saturated silt sediment, and load structures (pseudonodules, load casts) with a predominantly sandy fraction. Sediment lithology and its saturation were the key factors influencing the type and morphology of the SSDS.

Theme 5. Continental clastic depositional systems

General Session

Poster presentation

In search of sedimentological records of Quaternary earthquakes in central Europe

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The vast majority of Europe (with the exception of the Mediterranean Sea and Iceland) belongs to the penseismic or aseismic area, i.e. modern earthquakes occur there rarely or frequently but their magnitude is below 4. However, during Quaternary, seismic activity in central Europe was changed due to e.g. ice-sheet loading and unloading (GIA). The main goals of the study were identification of sites with evidences of Quaternary earthquakes as well as an attempt to identify potential areas with seismites. Seismites are sedimentological recorded of past earthquakes (seismites = layers with internally-deformed sediment). They are characterized by the presence of liquefaction-induced soft-sediment deformation structures (SSDS) resulting from seismic events. It is assumed that their formation requires magnitude M>4.2, and they occur up 30 km from the epicenter. Available geological data for each country surveyed were used and processed, taking into account, among others, geological structure, tectonics, geomorphology, sedimentology, as well as contemporary seismic activity. Then, a map of the susceptibility of the seismic-induced liquefaction of sediments was made. In addition, a statistical analysis of modern recorded earthquakes was performed, determining their statistical significance with other variables and the probability of seismites occurrence in the geological past.

Theme 5. Continental clastic depositional systems

General Session

Poster presentation

Sedimentological postcards from Ireland's earliest forest: biogeomorphological innovations recorded in the Late Devonian Harrylock Formation, Co. Wexford

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The mid-Paleozoic was a significant interval in the evolution of plants, during which their biogeomorphological influence on terrestrial landscapes increased substantially. Yet while such interactions are well known from Carboniferous strata, evidence in the Devonian record is less common. We present new evidence for plant–sediment interactions from the Late Devonian (Famennian) Harrylock Formation (County Wexford, Ireland), which hosts standing trees that represent Ireland's oldest reported fossil forest. The formation records deposition in fluvial and lacustrine environments, the former of which is here shown to host Earth's earliest known logjam and early examples of vegetation-induced sedimentary structures (VISS) and a vegetation-sustained chute channel. Fossil driftwood debris preserved in lacustrine facies within the unit also contains the earliest evidence for arthropod(?) borings, which serve to narrow the prolonged gap between the first occurrence of fossil wood and the earliest wood borings. Together these early examples show that plant-related phenomena, frequently associated with Carboniferous strata, were already in existence by the Devonian and may have been previously overlooked. Considering evolutionary changes in flora across the Devonian–Carboniferous boundary, the sparse early record of plant-related sedimentary phenomena can be explained by a lesser abundance and/or longevity of such features in Devonian landscapes.

Theme 6. Shallow-marine clastic depositional systems

Special Session 6.1. Coastal depositional systems: understanding past and modern systems for a resilient future

Keynote lecture

Cenozoic coastal peatlands and giant coal deposits, Gippsland Basin, SE Australia

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The Gippsland Basin has an almost continuous record of coal accumulation from the late Cretaceous to the Miocene. Ombrogenous peats of the Gippsland Basin accumulated in a back barrier environment, in close proximity to marine influence. These coals are some of the thickest in the world, with individual seams reaching over 100 m thick. The lower coastal plain paleogeography of the Gippsland Basin during the Paleocene and Eocene can be imaged in detail with 3D seismic amplitude extractions. These coastal to shallow marine environments are characterized by sand-rich coastal barriers and back barrier peatlands. Peatlands are well preserved, with the morphology of the preserved peat depositional environment changing up section. The Paleocene interval reveals irregular shaped ombrogenous peat domes separated by a complex network of highly meandering tidal channels. During the early Eocene, peat domes spread and encroached on channelized areas, reducing the influence of tidal channels on the lower coastal plain deposits. By the late Eocene, ombrogenous peat domes had intergrown, and formed an extensive, continuous coal layer, with minimal tidal channels. These extensive peatlands formed throughout global climate variations, at mid-high latitudes, with individual coal seams of the Paleocene–Eocene up to 12 meters thick.

Theme 6. Shallow-marine clastic depositional systems

Special Session 6.1. Coastal depositional systems: understanding past and modern systems for a resilient future

Oral presentation

Changing characteristics of wave-dominated and wave-influenced compound clinoforms in the rock record

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Compound clinoforms are well recognized in modern muddy deltas where strong waves, tides and currents redistribute sediment away from the shoreline clinoform across a bypass unit, the subaqueous platform, before depositing along the shallow dipping 1–2° subaqueous clinothem. However, there are few published examples of their changing facies characteristics in the rock-record. Facies analysis in the Lajas Formation, Neuquén Basin, and paleo-Orinoco Delta, Mayaro Formation, shows shared characteristics within their tripartite architecture that may give some of the defining features for wave-dominated and wave-influenced compound clinoforms. The thickness of the typical compound delta in each case is up to 70 m and 330 m respectively, due to contrasting subsidence rates.

The subaqueous clinoforms record several coarsening upward sub-units (10–40 m) of interbeds of laminated siltstones and dark organic rich mudstones 0.5–5 cm thick, passing upwards into wavy laminated sandstones, representing the distal location from the main storm events and fluvial input. The upper foreset to rollover has either HCS beds or sharp based erosional chutes filled with graded beds of sandstones to carbonaceous mudstones that downcut into the muddy interbeds. The overlying subaqueous platform deposits can be dominated by i) wavy bedded mudstones with siltstones and sandstones, having double mud-drapes, illustrating some tidal influence on the platform, downcut by shallow scours, up to 60 cm deep, infilled with normally graded sandstones and siltstones; or by ii) bioturbated sandstone beds that can alternate with cross-stratified or plane-parallel laminated sandstone beds. This suggests strong storms had adequate shear stress to erode the platform creating conduits to transfer sediments via wave enhanced sediment gravity flows and hyperpycnal flows across the shallow wide platform to the subaqueous rollover. The subaqueous platform is capped by the sharp based shoreline clinothem which is dominated by HCS and SCS sandstones indicating reworking by storms, or by mouth bars and tidal channels. The recognition of the energetic platform facies is significant in defining wave-dominated and wave-influenced compound clinoforms, as without it the succession would be expected to show basinward winnowing of sediments associated with single clinoform development.

Theme 6. Shallow-marine clastic depositional systems

Special Session 6.1. Coastal depositional systems: understanding past and modern systems for a resilient future

Oral presentation

Modern Danube river delta front evolution: geomorphic adjustments under anthropogenic pressures

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The majority of world river deltas are at present intensely affected by anthropogenic activities. One of the most damaging effects is the reduction of sediment supply due to damming in the river catchment and channelization inside the delta plain, which causes coastal erosion and thus ultimately endangering settlements on the delta plain. For this study we look at how Danube delta front responds to change from a natural to an anthropogenic regime by investigating the sedimentation rates reflected in bathymetric changes. We analyzed decadal bathymetric changes for six time intervals spanning the last approximately 150 years (between 1865 and present). For each interval a sediment thickness map was made. Before 1900, the Danube delta front records a net positive sediment budget outlined by a rapid shoreline progradation (> 50 m/year) of the Chilia (northern) lobe and a high deposition rate (0.8 m/year in the deepest part) in front of the Sfantu Gheorghe (southern) lobe. After 1900, the natural regime of the delta was increasingly affected by anthropogenic influence on the Danube river catchment and changed delta sedimentation patterns. Consequently, Chilia lobe faced a gradual decrease in shoreline progradation rates reaching 20 m/year in the 1920s and erosion on the coast exposed to dominant waves, starting with the 1940s. The engineering works which started in the 1860s at the Sulina mouth extended the channel mouth jetties transforming the Sulina distributary in a shipping channel. The jetties extension enhanced erosion in the downdrift part of Sulina mouth due to local wave diffraction. Furthermore the Sulina jetties blocked the southward longshore sediment transport which deprived the southern Sf. Gheorghe lobe of the sediment supply generated by the Chilia mouths. This effect, together with the constantly decreasing overall river sediment input and increased storminess on the deltaic coast led to intensification of wave processes reworking Sfantu Gheorghe river mouth sediments and fast migration (0.2 km/year) of the depocenter toward the southern tip of its barrier island Sacalin. The effects of this human intervention are also reflected in the shrinkage of sediment depocenters identified on bathymetric maps and their southward migration.

Theme 6. Shallow-marine clastic depositional systems

Special Session 6.1. Coastal depositional systems: understanding past and modern systems for a resilient future

Oral presentation

Seismite in Lake Pannon? – Signatures of an extreme event on a sandy delta plain

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Metre-scale load and water-escape structures, sedimentary dykes are commonly induced by earthquakes, however they can also refer to other shocking depositional processes like storms or tsunamis. These kind of soft-sediment deformational structures can develop in all sort of environments. Here we present a Late Miocene lacustrine deltaic succession from the southwestern part of the Pannonian Basin, Hungary. Deposition occurred on the northern shore of the several hundred meter deep Lake Pannon at about 7 Ma (*Prosodacnomya* Zone).

The lower part of the succession consists of fossiliferous bioturbated mudstone with thin, cross-laminated sandy interbeds. Thickness of sand increases upwards, trough- and hummocky cross-stratification, and rip-up mud clasts occur. These are interpreted as interdistributary bay-fill deposits. The next 5 m thick interval is mostly made up of sand with metre-wide, up to 0.5 m high load balls and flames in the basal part. The following sand is amalgamated with chaotic water-escape pipes, but most other structures are obscured by large concretions except for some planar lamination. The overlying structureless sand contains intact mollusc casts. The upper part of the succession, alternation of mudstones with thin cross-laminated and thick structureless sand beds, points to the delta plain again.

The sudden change in lithology from heterolithic beds to sand-dominated with large-scale soft-sediment deformation structures suggests rapid deposition of large volume of sand over the unconsolidated beds. Planar lamination, thick structureless sand and strangely mixed mollusc fauna from different lacustrine environmental zones together may point to extreme wave events flooding the delta plain. Some follow up shock may have triggered density inversion at the base and generated liquefaction in the overlying sand. These could have been initiated by an extremely large storm, some tsunami waves or an earthquake. Such big storms are not likely to occur in Lake Pannon. Earthquakes cannot be ruled out. Slumps detected on seismic profiles were common on the slopes of Lake Pannon which may have triggered tsunamis. On rocky shores of Lake Pannon bouldery tsunamites were formerly described, but these remain hidden so far in the extensive deltaic successions.

Theme 6. Shallow-marine clastic depositional systems

Special Session 6.1. Coastal depositional systems: understanding past and modern systems for a resilient future

Poster presentation

Depositional environments along an arid coast and its implications for dispersal processes to basinal settings: case study along eastern margin of the silt-dominated, Lower Triassic Montney Formation of the Western Canada Sedimentary Basin

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Arid coastal settings commonly consist of a mosaic of aeolian, fluvial and shallow marine depositional environments, which shift spatially and temporally influencing sediment distribution over time. Sediment delivery to marginal marine and basinal settings along arid coastlines is dependent on the complex relationship between wind-blow sources and fluvial input from both perennial and ephemeral rivers/deltas. Many studies have described erg-margin settings within ancient and modern localities and their interfingered relationship with marine coastal deposits; however, such study has not been conducted for the Lower Triassic Montney Formation of the Western Canada Sedimentary Basin due to terrestrial and marginal marine deposits being eroded away by intraformational and extraformational unconformities. Based on paleogeographic reconstruction, an arid coastal margin has been classically ascribed to the Lower Triassic for western Canada, and many have suggested that the aerially expansive and thick (up to 350 m), fine- to coarse-grained siltstone-dominated formation is mainly sourced from wind-blown sediments. In this study, facies analysis was conducted on drill cores located within Alberta, Canada to better understand the depositional environments along the eastern subcrop edge of the Montney Formation. Depositional environments observed in core include a 5–20 m thick succession of fluvial-dominated delta in the south, and 5–10 m thick wave-dominated delta and strand plain to the north. Within the deltaic environments, fining upward beds (10–50 cm in thickness) are made up of fine to medium sand at the base and are capped by organic and clay-rich beds. Additionally, deposits associated with barrier island (coquina), lagoon, tidal flats, and sabkha are observed, suggesting a more complex coastline than previously thought. Through facies mapping, an evolution and extent of these depositional environments can be constructed to show the dynamic nature of the eastern Montney coast through time and their potential contribution of sediment delivery to the offshore environments. This example acts as a case study for other fine-grained systems from around the world and highlights the importance of evaluating shoreline successions within source to sink studies.

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Poster presentation

Sedimentary architecture of the UGS Dolni Dunajovice

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The poster presentation is devoted to the issue of the underground gas storage Dolni Dunajovice that is with an average length of 8 km and a width of 800 m the biggest reservoir of gas in the Czech Republic. The study concerns the geological development of the southern part of the Western Carpathian Foredeep (peripheral foreland basin) in Moravia, especially during Miocene, when the Eggenburgian Dunajovice sandstones were laid and which create a gas storage horizon.

The actual research is built on the study of drilling cores and well logging measurements. Examined are the contents of heavy minerals mainly zircon, tourmaline, staurolite, rutile, garnet and their probable origin from metapelites of Moravicum and the Cadomian granitic rocks of the Brno massif. These results are also compared with laboratory gamma-ray spectroscopy and geochemistry analysis, which gives a proper view of the provenance and paleoenviroment of the area of interest. In addition, the representation of grain fractions is evaluated and which in combination with the variable contains of organic matter and glauconite reflects a variable sedimentation environment. Facies analysis with interpretation is also an output of the core study and is evaluated in combination with well logging (Gamma ray, resistivity, SP) in the whole area of the reservoir in Petrel program.

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Poster presentation

The role of an intensified Early Holocene summer monsoon on the sedimentation and stratigraphic evolution in the macrotidal embayment, mid-western Korea

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Coastal deposits in western Korea consist of a coarsening-upward succession formed during post-glacial sea-level changes. Transgressive sedimentation and stratigraphic evolution are known to be associated with the interaction between tide and wave. However, the climate influence that controls the sediment loads into the coastal area remains uninvestigated. Up to 25-m-thick successions in the Gomso Bay start from basal fluvial deposits (DU1) that grade upward into mud beds with interlaminated silt and mud (DU2), moderately bioturbated, interlaminated sand and mud (DU3), and wave-rippled sands with interlaminated sand and mud (DU4). DU3 contains 2 to 5 cm thick structureless mud beds, which alternate with interlaminated silt and mud, showing double mud drapes and cyclic changes in laminae thickness resembling tidal cycles. A common occurrence of terrestrial plant fragments, dated 8 to 11 ka (calibrated yr BP), and fluctuating $\delta^{13}C$ values suggest that tide-driven sedimentation is interrupted by fluid mud deposition associated with fluvial floods due to an intensified early Holocene summer monsoon within a macrotidal embayment. Gradual weakening of the summer monsoon and continued sea-level rise have led to tide-dominated sedimentation in the Gomso Bay until the sea level reaches its present position around 7 ka when a wave-dominated mixed energy condition starts to prevail. The present study showcases that summer monsoon has dominated sedimentation and stratigraphic evolution during the early Holocene rapid sea level rise in the fluvial–tidal transition of a macrotidal embayment with a meager fluvial input.

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Poster presentation

MISS generated in a temperate hypersaline relic estuarine saltpan, with current continental influence

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The Salitral de La Vidriera (38°44'S, 62°34'W), once part of the Bahía Blanca estuary (~3000 years BP), is currently a continental saltpan, that acts as a hypersaline evaporitic environment. This study provides a first-hand characterization of the epibenthic microbial mats that biostabilize its surface sediments, and the environmental dynamics and physical deformation agents behind the formation of modern Microbially Induced Sedimentary Structures (MISS).

MISS and sediment cores were sampled on five field trips from Dec 2020 to Nov 2021, comprising all consecutive seasons in a year. The organic matter (OM) content was quantified by the mass LOI method, and granulometric (Malvern Mastersizer particle analyzer) and petrographic (Nikon Eclipse POL 50 transmitted light microscope) analyses of sediment were performed. Environmental parameters in water and sediment were recorded in situ. The community of photoautotrophic organisms in mats was characterized by light microscopy and the chlorophyll a content (a proxy for biomass) was estimated spectrophotometrically.

The MISS identified were reticulate surfaces, pinnacles, gas domes, desiccation cracks, folds and wrinkles, mat chips, flipped-over mats, and roll-up mats. Gypsum crystals were found in surface and subsurface sediments and carbonate precipitation was corroborated through petrographic analyses. The microbial community in the hypersaline mats responded seasonally and was dominated by filamentous (*Oscillatoriales*) and coccoid cyanobacteria (*Chroococcales* and *Pleurocapsales*). The processes behind the MISS genesis involve an interplay between hydration, the flexibility and cohesion conferred by microbial colonization, and physical deformation exerted by hydrodynamic wind-generated currents. The sediment cores had a homogeneous texture; while it was not possible to identify a record of microbial mats, average OM content was > 10% in the upper 10 mm and remained ≥ 5% throughout the 80 mm of cores. Gypsum crystals are produced by rainwater evaporation, and preserved by mat recolonization. The micritic carbonate precipitation is characterized by peloids morphology rather than laminae. The high content in autotroph pigments, OM and carbonate precipitation highlight the potential role of this environment as a sink for atmospheric carbon.

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Poster presentation

Impact of submarine karstic sulfur rich springs on sediment environment (Izola, northern Adriatic Sea)

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This work highlights the sediment features and the role of submarine sulfur rich karstic springs in distribution of benthic foraminifera. The submarine sulfur springs appear in the funnel-shaped depression (more than 10 m deep) on the seabed along the coast between Izola and Strunjan in the northern part of Adriatic Sea (Bay of Koper). Little is known about how local conditions, like temperature, sulfur bursts and springs activity, can influence sediment characteristics, such as mineralogy, geochemistry and organic matter, as well as benthic habitat variability and composition of foraminiferal assemblages. Here we compare the distribution of total and living benthic assemblages in surface sediments samples that were collected at the bottom of depressions around submarine springs. Sampling was performed at water depth between 25 and 32 m in fine-grained sandy silt to silty sand (partially washed). In general, mineralogical and geochemical characteristics around the sulfur springs do not show prominent deviations from the uncontaminated sediment of the area, however, some differences do exist. This may indicate a different type of sediment at its origin. From five studied samples, one (Bele skale) contained living foraminifera in abundance to study the biocenosis. The benthic foraminiferal assemblages of moderate diversity are composed of opportunistic species. *Elphidium translucens*, *Ammonia* ex gr. *tepida*, *Haynesina depressula*, *Porosononion granosum*, dominate, while *A. neobeccarii*, *Reusella spinulosa* and *Textularia bocki* are subordinate. Foraminifera distribution and diversity in sediment near the sulfur springs can be explained by different factors and their interactions. The intensity of the spring outflow influence on sediment mixing/oxygenation, the shape of spring depressions, and on higher sediment granulometry around the springs. The sediment characteristics (i.e. mineralogical, geochemical, and organic matter) indicate different types of sediment origin. This is also associated with the depth of depressions of the springs; deeper depressions in the lower parts likely reach older Late Pleistocene continental sediments with alluvial characteristics, while shallower depressions are formed entirely in the Holocene marine sediments.

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Special Session 6.2. Mixed process expressions, and controls on sedimentation in tidal systems

Oral presentation

Interaction between physical and microbial processes in a coastal modern environment: the stabilization of flaser and wavy bedding

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Benthic microbiota in clastic deposits can greatly contribute to the stabilisation of sedimentary structures such as ripples. While microbial activity is typically favoured in low-energy environments, flaser and wavy bedding are formed in environments recurrently affected by high-energy typically-tidal currents. However, this study documents the participation of microbial activity in the stabilization of flaser and wavy bedding in a coastal flat.

The study area, Paso Seco (Argentina), is an elongated supratidal area (3.5 x 0.4 km) perpendicular to the coast with a narrow mouth. The zone is inundated intermittently by seawater only during storm surges, creating a high-energy environment at the mouth where fast water currents erode slightly the bottom sediment, creating a semi-permanent pond. During floodings, sand ripples are formed, and when the energy diminishes, fine-grained sediments fall out of suspension, draping the bedforms with mud. During calm conditions after the storm, field observations reveal a cyanobacteria biofilm that covers the bottom of the pond, coating sand ripples and mud, and forming reticulate structures with Oxygen-bubbles.

Microbial activity is recognized in the surroundings: the subaerially exposed areas adjacent to the pond exhibit stabilized ripples or planar surfaces colonized by microbial mats. Moreover, microbial mats remain hanging from the eroded border of the pond, and thread-like structures enriched in organic matter are piled up against the pond margin. Sedimentary cores reveal flaser and wavy bedding in the sediments. In addition, optical microscope and SEM studies show the presence of filaments of cyanobacteria and EPS in mud sediments, and filaments of different sizes entangling sand grains. The hydrodynamic of the zone is characterised by a few days of inundation due to storms (high-energy period) when the sand ripples are formed, followed by the receding of seawater, which can last up to several months during a calm state. The quiescence period provides optimal conditions for bacterial colonization of sediments underwater, allowing the formation of a coherent cyanobacteria biofilm. This microbial layer protects the flaser/wavy bedding from erosion. Thus, the interaction of microbial and physical processes creates the flaser and wavy bedding.

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Special Session 6.2. Mixed process expressions, and controls on sedimentation in tidal systems

Keynote lecture

Characterizing mixed-energy environments using sedimentary structures

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Determining the relative importance of rivers, waves and tides in the accumulation of an ancient succession is necessary in order to select the correct geomorphic model for the geometry of geobodies. Sedimentary structures record the processes responsible for sediment accumulation, and both qualitative and quantitative approaches to using them to characterize paleo-environments have been attempted, based on the relative abundance of structures produced by each process. It is notable that wave action and river discharge commonly occur as high-energy events of relatively short duration (i.e., hours to days for storms; days to weeks for river floods), whereas tidal processes operate continuously. Because of this, the record of wave and river action commonly occurs as discrete event beds, whereas the tidal record is most likely to be expressed in the inter-event (background) deposits. In both river and wave influenced to dominated settings, high-energy events tend to erode the preceding lower-energy deposits, creating a biased record that minimizes the evidence of tidal action. Conversely, if abundant low-energy deposits are preserved, the record of tidal action might be over-emphasized leading to unrealistically high estimates of tidal action. In fluvial settings, the presence of tidal modulation of current strength and direction within river-flood deposits is a valid indicator of strong tidal influence or even dominance at the site of deposition, although not necessarily in the entire system. In settings where wave action is significant, evidence of tidal modulation within storm beds might not be equally significant if the modulation is a result of tidally generated water-depth changes, because tidal range is not strongly correlated with the speed of tidal currents along open coasts. Thus, simple tabulation of the relative abundance of various sedimentary structures might not give an accurate assessment of the nature of the environment because of failure to appreciate when the various structures were formed (high- versus low-energy periods), preservation bias, and the presence of tidal effects that did not contribute to generation of the depositional morphology. Spatial variability in relative process intensity and preservation add more complexity to the characterization of larger depositional systems.

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Special Session 6.2. Mixed process expressions, and controls on sedimentation in tidal systems

Oral presentation

Tidal shorefaces and their rock record expression: a unifying model and refinement of the coastal-environments classification scheme

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The introduction of tidal shoreface models to the sedimentological literature addressed a gap in the classification of coastal depositional systems, which are normally classified based on the relative importance of wave, tide, and river processes. Two tidal shoreface models have been proposed, open-coast tidal flats (OCTF) and tidally modulated shorefaces (TMS), and these are combined into a single tidal shoreface model with consistent sedimentological and stratigraphic attributes. First, tidal shoreface successions are preferentially preserved in low- to moderate- wave energy environments and in progradational to aggradational systems. It is probably difficult to distinguish tidal shorefaces from their storm-dominated counterparts. Second, tidal shorefaces should exhibit deposits resulting from tidal modulation of wave/storm processes throughout the succession, and with increasing prevalence landward and seaward of the upper shoreface. The development of a single tidal shoreface model sheds light on the limitations of the presently accepted wave-tide-river classification scheme of coastal environments and a revised scheme is presented. In particular, tidal flats are components of larger depositional systems and are typically impacted by wave processes to some degree; consequently, they should not represent the tide-dominated end-member of coastal systems. Instead, we suggest that tide-dominated embayments should occupy this apex. Tide-dominated embayments exhibit limited wave and river influence and include a wide range of geomorphological features typically associated with tidal processes, including tidal channels, bars and flats.

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Oral presentation

The regressive surface of marine erosion in tidal sand ridges based on drone and field data

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The regressive surface of marine erosion is a key discontinuity indicating episodes of forced regression in marine strata. This feature, which is referred to the basal contact of shallow-marine (e.g., shoreface, deltaic) deposits erosionally overlying relatively deeper-water (e.g., shelf, prodelta) lithofacies, has been documented in marginal-marine depositional systems, whereas less is known for offshore or strait settings. In this study, we investigate a series of exceptionally well-exposed stratigraphic sections of lower Pleistocene strata cropping out in the Plio–Quaternary Siderno Basin, southern Italy. The deposits form a series of outstanding cliffs, for a maximum thickness of 80 m and for a total length of ca. 2 km. They are known to record a series of tidal sand ridges, developed in this part of the Mediterranean due to marine strait condition and consequent energetic tidal current amplification flowing bi-directionally between two interconnected larger basins. An uninterrupted vertical/lateral exposure of these outcrops allowed us to acquire drone-based high-resolution images of the entire succession and, specifically, of the basal surface that marks the onset of tidally-dominated sedimentation. This discontinuity, which gently dips basinwards and abruptly separates underlying shelf fines from overlying cross-stratified, tidal bioclastic/siliciclastic arenites, records a long-lasting stage of marine regression in a non-marginal strait setting. Ridges' stratal architectures indicate dominant cross-bed aggradation in the most internal (up-current) succession, transiting down-current into balanced aggrading/prograding stratasets and, further basinwards, into markedly prograding deposits. These features are here interpreted as the record of an initial phase of normal regression, turned into a forced regression. This latter stage is indicated by a deepening of the basal discontinuity, becoming even more erosional onto the underlying beds, accounting ca. 60 m of vertical basinward fall in less than 2 km of horizontal length. The major engine was the tectonic uplift of a sill (the Aspromonte Ridge) located in the center of a ca. 50-km-wide strait system, during which a series of tidal sand ridges in the eastern side of the strait developed in the Early Pleistocene.

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Oral presentation

Facies architectures of a Mesoproterozoic fan delta, Rajgarh Formation, North Delhi Fold Belt, NW India

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The Mesoproterozoic Rajgarh Formation (Alwar Group) hosted conglomerate–sandstone package at the lower part of the succession within the NE–SW trending Lalsot Basin, North Delhi Fold Belt, NW India. Sedimentation in the studied section is constituted of 11 facies types, grouped under three major facies associations: (i) subaerial fan facies association characterized by stacked sediment gravity flow deposits; (ii) tidally modified mouth bar facies association characterised by subaqueous emplacement of hyperpycnal and gravity flows with the subsequent reworking of the tidal currents in the delta front, and (iii) tidal platform facies association characterised by sandstone–mudstone heteroliths with tidal signatures and intermittent wave reworking in a relatively stable platformal setup. Towards the proximal part the subaerial component was dominated by the debris flow deposits (FA-1) followed by their channelised subaqueous emplacement. Tidal modulations of these sediments (FA-2) led to finning-upward sequence above alluvial fan facies. Laterally this subaerial gravity flows were succeeded by more diluted density currents and graded onto subaqueous delta front. Vertical growth of the mouth bars (FA-2) were controlled by flattening and acceleration of the fluvial jet and formed scour channel on the bar top that led to the expansion of the mouth bar and channel break through the front of the mouth bar. The lower part of the delta front (FA-2) succession is characterised by slump deposits, pebbly dominated cosets with significant deformed structures, whereas the upper part of the delta front succession shows gradual reduction of pebble abundance and the thickness of cross-strata cosets. The alluvial fan feeder and basinal processes redistributed the sediments and flushed the finer sediments into the stable platformal tidal flat settings (FA-3) beyond the influence of the upslope gravity flow surges. Overall facies sequence and the resultant stratal architecture signify the effects of changing sea level and the hinterland tectonics leading to variation in the sediment influx on the net accommodation space during the early stage of basin evolution in the southeastern part of the North Delhi Fold Belt.

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Oral presentation

Sedimentology of the Myeonsan and Myobong formations, eastern Korea: a siliciclastic tide-dominated succession formed during Early Cambrian transgression

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The Myeonsan and Myobong formations of the basal Taebaek Group (Cambrian Stage 3?–middle Wuliuan) represent the early stage of Cambrian transgression on the eastern end of the Sino–Korean Block. During the initial stage, localized alluvial fans of the Myeonsan Formation developed on Precambrian basement, and were submerged as transgression continued. The overlying lower Myobong Formation is dominated by lenticular bedded deposits that formed in muddy intertidal flats. Continued transgression resulted in tidal rhythmites likely deposited on lower intertidal to subtidal flats. The uppermost Myobong Formation is characterized by a bioturbated lower shoreface succession overlain by carbonate shoals of the Daegi Formation. Overall, the Myeonsan and Myobong formations show a general deepening pattern of tide-dominated siliciclastic sediments prior to the development of an extensive carbonate platform. Recognition of a similar sedimentation pattern throughout the Sino–Korean Block suggests platform-wide transgression (Meng et al., 1997). This pattern is best studied in Shandong Province, China, ~1,000 km west of the study area (Lee and Chough, 2011) which can be biostratigraphically correlated with the Taebaek Group based on the same trilobites. In both Taebaek and Shandong, sedimentation was initiated around Cambrian Stage 3, and then overlain by intertidal successions. Transition to deeper tidal flat conditions occurred in early Cambrian Stage 4 in both areas. With decreasing tidal effect, a coarser sandstone dominated succession developed in both areas, which was then overlain by thick platform carbonates in the late Wuliuan. This sedimentologic comparison demonstrates rapid filling of irregular palaeotopography during the initial stage of second-order flooding on the tectonically stable Sino–Korean Block. In contrast to the Cambrian of Laurentia, where topographic filling commonly required at least several tens of million years, our result suggests that in the Sino–Korean Block a similar process may have been accomplished within several million years.

References

Lee and Chough (2011) Sedimentology, 58, 1530–1572.
Meng et al. (1997) Sed. Geo., 114, 189–222.

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Oral presentation

Sea-level changes and strait topography control sedimentary evolution of the Taiwan Strait

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The straits represent a unique depositional environment that is distinguished from other marine settings in having distinct sedimentary processes and facies distribution. The sedimentary processes (tidal current, wave, and ocean currents) are largely controlled by relative sea-level changes and topography, which are associated with openings and closings of the straits. Previous studies have demonstrated that tidal currents are the dominant processes that are responsible for sediment accumulation in many short (<100 km long) and shallow straits (<100 m in water depth). The sedimentary evolution of non-tidal-dominated straits is largely un-investigated. The topography of the long Taiwan Strait results in stronger tidal currents near the two strait mouths and very weak tidal currents towards the center, which represents a non-tidal-dominated strait. This paper synthesizes the previously published data, new core data and chirp profiles, to investigate sedimentary evolution of the Taiwan Strait. Three regional unconformities identified in the seismic sections probably correspond to sea-level lowstands associated with the Last Glacial Maximum, MIS 4 and MIS 6. The integrated sedimentology and provenance study show that the lowstand deposits are dominated by sedimentation of local rivers and deltas. During transgression, the local fluvial and deltaic contribution decreased whereas the contribution from Changjiang and Taiwan sources increased, probably deposited by ocean currents. The highstand periods are characterized by dominant contribution from the Taiwan and distant Changjiang sediments. The highstand system tract contains deposits of the Changjiang Coastal Mud Belt and sediment mound in the central strait that are interpreted as shallow-water contourites. We demonstrate that how the entered wave reworked the contourite drifts through shaping sedimentary architecture. Coastal mud belts and mounded contourite drifts, such as those observed in the Taiwan Strait, may represent an important component of shallow-strait successions around the world, which are also contrasts to the existed facies model of tidal straits.

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Poster presentation

From concept to reservoir modelling: the record of tide-dominated, progradational shoreline systems

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Facies models for sedimentary systems developed at progradational, tidal dominated shorelines (e.g., open coast tidal flats and tidal deltas) are relatively underdeveloped in comparison to models of tidal systems developed in transgressive contexts. As such, they have been less identified and modelled in subsurface scenarios. These systems are characterized by the complex interaction in space and time of tidal currents with fluvial and wave processes, resulting in very heterogeneous deposits. The complexity of the resulting sedimentary record provides an excellent opportunity to implement a rule-based reservoir modelling approach. In this contribution, we explore how to place tidal deposits in a rule-based framework, as we build on previous experience reproducing the facies geometries of wave-dominated shoreline successions. We have reviewed modern and ancient examples to define the geological elements of different hierarchies that conform these systems and that are also preserved and identified in the geological record. Furthermore, we have explored the geometry and scale of these elements, and how they are spatially related. As a result, we define a basic set of rules and parameters that can be implemented to model reservoirs of this type. In the process, we raise questions that will challenge current conceptual models for progradational tidal dominated shorelines and help their development. We expect that the development of this method can be a powerful tool to produce useful models for reservoir assessment regarding different interests (oilfield exploration and development, CO_2 storage projects, etc).

Theme 6. Shallow-marine clastic depositional systems

Special Session 6.2. Mixed process expressions, and controls on sedimentation in tidal systems

Poster presentation

Sand-rich, mixed-energy, tide-influenced deltaic system: Upper Jurassic–Lower Cretaceous Bidu Formation, Central Iran

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Main goal for studying Upper Jurassic–Lower Cretaceous sand-rich deltaic succession of Bidu Formation in Central Iran was to characterize sediment architecture and inferred depositional processes operating in shoal water, mixed-energy delta. The work is based on lithofacies analyses and trace fossil studies. Logging of 2 km long and 300 m high exposure yielded excellent data for interpretation of spatial architecture of the observed sediments. Results: We defined five facies associations: upper and lower delta plain, subaqueous delta platform, delta front and prodelta. Upper delta plain includes fluvial channels and paleosols. The fill of fluvial channels consists of extrabasinal conglomerate and sandstone with an erosional base. Lower delta plain is represented by channelized bodies of fine to medium sandstone incised into siltstones or silty sandstones interpreted as distal distributary channels and interdistributary bay deposits, respectively. The subaqueous delta platform shows tidally and wave-reworked mouth bars, dunes and heterolithics. The mouth bars are typified by fine to medium sandstone with occasional strata of granule to pebble of intrabasinal material. Typical is parallel lamination, ripple cross lamination, bidirectional cross-stratification, coarsening-upward trend, mud drapes, flaser beds. The tidally and wave-reworked dunes consist of cross-stratified and massive, often amalgamated sandstone. Delta front facies are typical by very fine and fine, massive and cross-stratified sandstone. Climbing ripples are common. The sediments may show intensive deformation. Prodeltaic environment consists of siltstone and very fine sandstone. They are massive and ripple cross-laminated. The analyzed sediments show the main tidal signal in the subaqueous platform and, less, in the lower delta plain. The wave activity is mostly seen in subaqueous mouth bars, dunes and delta front facies. Fluvial signature is most obvious in the upper delta plain. Conclusion: The succession of deltaic deposits suggests an overall regression emphasized by a progradation of fluvial channels filled with extrabasinal clasts in the upper part of the succession. The detailed logging shows some 25 small-scale cycles consisting of progradational and retrogradational units.

Theme 6. Shallow-marine clastic depositional systems

Special Session 6.2. Mixed process expressions, and controls on sedimentation in tidal systems

Poster presentation

Deltas affected by longshore currents: insights from numerical model

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Deltas are dynamic and sensitive systems that undergo changes of morphology, channel network, and stratigraphic architecture in response to variations in discharge, sediment supply and marine processes. A new and understudied topic is the morphodynamic evolution of deltas prograding into a strait or seaway characterized by longshore currents. These currents can have a variety of origins (meteorological, coastal-oceanic, or tidal). Numerical modeling can help researchers to better understand the evolution of deltas in relatively narrow passageways, where fluvial floods are largely reworked by laterally varying waves and/or tidal processes. This study uses Delft3D to investigate the influence of coast-parallel tidal currents on river-dominated deltas in terms of deltaic morphology and stratigraphic architecture. We have conducted a number of modeling runs to simulate a scenario where two basins are connected by a very short (due to computational constraints) strait. The longshore currents are created by setting tidal phases in the connected basins out of sync and therefore creating a water elevation imbalance between the two. Initial modeling results show the deformation of a deltaic body under the coast-parallel currents occurs even with small differences of water elevation between the connected basins and even small longshore currents might have an impact on the morphology of the deltaic bodies.

Theme 6. Shallow-marine clastic depositional systems

Special Session 6.2. Mixed process expressions, and controls on sedimentation in tidal systems

Poster presentation

Reconstruction of tidal–fluvial processes in the eastern part of the North Sea Basin during the Lower Miocene, northern Poland

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The siliclastic deposition during the Upper Oligocene–Lower Miocene in the northern Poland developed as the balance of two main tectonic processes – subsequent uplift of the Scandinavian area in the north and formation of the Polish Carpathian peripheral foredeep basin in the south. Between them a vast area of fluvial, paralic and shallow marine depositional processes took place. The Miocene in the southern part of Poland is well recognized due to excellent exposures in the Carpathian Mts and numerous oil-gas drillings. Also central Miocene basin with vast lignite deposits is described in detail, whereas northern part is less documented. Exposures of the Miocene siliclastic deposits in the cliff sections along the present-day Southern Baltic and Gulf of Gdańsk give an opportunity to detailed sedimentological studies. The main goals of the studies are: (i) to establish origin of the studied deposits; (ii) to reconstruct a succession of depositional processes; (iii) to construct a new palaeogeographical model for peripheral part of the eastern North Sea gulf in the Lower Miocene. Studies led to identify several sedimentary facies: tidal flats, estuary channels, tidal marshes and offshore. Their lateral and vertical succession reveals several transgressive–regressive pulses, fed by products of chemical weathering and erosion of the Scandinavia area, transported by river systems to the sea coast. The transport was from north and north-east and material was replaced by tidal and littoral currents along the coast.

Theme 6. Shallow-marine clastic depositional systems

Special Session 6.3. Coastal boulder deposits (CBD) as archives of extreme wave events

Oral presentation

Cape Town's fossil beaches aid in reconstructing Pliocene shoreline dynamics

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Gravelly sediment layers in fossil beaches around the Cape Peninsula and False Bay in South Africa are assumed to be Pliocene in age and are essential for reconstructing the ancient sedimentary dynamics along the shoreline in the greater Cape Town region. The cobble- to boulder-size clasts that dominate these fossil beaches point to a genesis that is likely linked to the erosion of local rocky shores during Pliocene hurricanes and "super storms". This mode of formation seems similar to the Pliocene fossil beaches located at different elevations around the world (aka 'the Pliocene sea-level paradox'). Although mapped for c. 100 years, to date, no modern sedimentological study has been conducted on Cape Town fossil beaches. Clast characteristics (e.g., clast size, sorting, roundness, composition) of the gravelly layers had been quantified in the field and by the processing of field image using ImageJ software. Our results, thus far, show that the fossil beaches are dominated by cobble-sized orthoquartzite (Peninsula Formation) clasts that are rounded, clast-supported and display a variety of percussion marks. The gravel size decreases from east to west, and the maximum clast size of 3.21 cm is recorded at Kogel Bay in False Bay. To ascertain the age, provenance and placer potential of these fossil beaches, the microfossil and heavy mineral contents of the finer-grained units (i.e., extremely rare, sandy matrix between cobbles) are being targeted for further analyses. Overall, this ongoing project, via its combined sedimentological, stratigraphical, and petrographical approach, hopes to achieve a meaningful comparison with other Pliocene boulder beds globally, and ultimately refine the Pleistocene marine dynamics of the Cape Town region and beyond.

Theme 6. Shallow-marine clastic depositional systems

Special Session 6.3. Coastal boulder deposits (CBD) as archives of extreme wave events

Oral presentation

Monitoring coastal boulder deposits in the Bahamas: records of past hurricanes and future storm-impact baselines

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Long-term monitoring of coastal boulder deposits (CBD) on small, low-relief, tropical carbonate islands in the Bahama Archipelago offers invaluable insights into understanding storm hazards and developing mitigation approaches. Aided by high-resolution drone imaging and RFID (radio frequency identification) tagging of storm-generated and transported limestone boulders, such CBD monitoring produces compelling datasets for use in communication with stakeholders about coastal vulnerability in times of ongoing climate change and sea-level rise.

Our monitoring of CBD on San Salvador since 2012 has documented modifications by Hurricanes Sandy (Oct. 2012), Joaquin (Oct. 2015), and Matthew (Oct. 2016). Significant changes were documented after Joaquin, which passed directly over the island as a strong Category 3 hurricane with about 190–210 km/h sustained winds. Storm waves overtopped cliffs, 3–5 m in elevation, along the high-energy southern coast and modified the formerly sharp-crested, narrow CBD ridge into a broad field, stripped of vegetation. New boulders, as large as 3 m in diameter, were generated, and blocks from prior storms, weighing 1–3 tons, moved up to 26 m inland. Calculated flow velocity needed to initiate their transport ranged from 2.6 to 5.7 m/s according to equations by Nandasena et al. 2011. The seaward edge of CBD moved landward 4–5 m, exposing a Pleistocene/Holocene boundary *terra rossa* paleosol and marking extent of storm erosion.

RFID tagging of small boulders and cobbles in 2019 substantially increased our database and, in conjunction with drone imaging in 2020, allowed us to document the impact of winter storms to the reef- and lagoon-protected site on the island's gently seaward-sloping northern coast in the absence of hurricane activity. Smaller size and better rounding of clasts indicate their more frequent movement by waves at this site, but the combination of RFID and drone-acquired data provide information about the amount and direction of their transport that would otherwise not be readily available. The new database also includes digital surface maps and transects through CBD at the two study sites for future comparative analyses of their response to storm impacts.

Theme 6. Shallow-marine clastic depositional systems

Special Session 6.3. Coastal boulder deposits (CBD) as archives of extreme wave events

Oral presentation

Extreme wave boulders at Fenoliga (Premantura, Croatia): inventory storm "footprints" in the northern Adriatic Sea

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Extreme storm events are expected to increase their impact on rocky coasts due to global warming. In recent years, coastal boulders moved by storm waves have played an important role in coastal dynamics. A key indicator of the magnitude of a storm wave includes precisely coastal boulders detached from the bedrock. First studies regarded deposits of boulders related to tsunami events, but recently many sites with large clasts related also to storm waves have been reported, also in semi-enclosed shallow basins, such as the Adriatic Sea (Mediterranean area). In this study, the mapping of coastal boulders at Premantura promontory (southern Istria, Croatia), has been expanded at other nearby localities in order to better understand the role of coastal topography in boulder deposition. In particular, we present and discuss the role of boulder deposits at Fenoliga Island, the most exposed site in the studied area. The investigation of the position, size, and direction of boulder movements was carried out using the UAV-DP (Uncrewed Aerial Vehicle – Digital Photogrammetry) and SfM (Structure from Motion) techniques, providing high-resolution data and used to create a 3D model of the island of Fenoliga, with a DEM and orthomosaic produced for boulder mapping. Approximately, 600 boulders were identified and categorized using the Qgis platform, and their validation was confirmed through the comparison with traditional geomorphological investigations. Boulders were identified and categorized using UAV-DP products, and their validation was done through the comparison with outputs of traditional geomorphological investigations such as field surveys, the axis measurement, and the use of Google Earth images for boulder mapping. Field evidence suggests that the studied boulders were dislodged, transported, and deposited by extreme storm waves, formed in situ due to the detachment of limestone layers, and moved inshore by increased water pressure during extreme events. The use of UAV-DP and SfM techniques provides high-resolution data for accurate boulder mapping, while the analysis of boulder deposits provides valuable information on the impact of extreme wave events on rocky coasts. The outputs of this study can be applied to other coastal regions and provide a better understanding of coastal hazard assessment.

Theme 6. Shallow-marine clastic depositional systems

Special Session 6.3. Coastal boulder deposits (CBD) as archives of extreme wave events

Poster presentation

Coarse-clast storm deposit and solitary boulders on the island of Mana (NP Kornati, central Adriatic, Croatia)

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There is growing evidence that many large coastal boulder deposits found on the exposed rocky ocean shores were deposited by extreme storm waves rather than by catastrophic tsunamis, as previously thought. In addition, before the first discovery in the northern Adriatic a few years ago, such deposits were not expected in relatively shallow semi-enclosed inland basins. Here we report on a large coastal coarse-clast deposit on the central Adriatic island of Mana, which also contains numerous large storm boulders that weigh up to several tons. Large solitary boulders are also located outside of the deposit, closer to the partly submerged sea cliff and the wave impact. The erosion of the cliff top and displacement of the carbonate bedrock fragments began when the extreme waves inundated the lowermost part of the cliff edge, probably during the late Holocene sea-level rise. The UAS photogrammetry-based fragmentation analysis of the storm deposit and the calculated fractal dimension value indicate that the material was fragmented by multiple high-energy events. A comparison of the available photographs indicates that displacements of the most exposed solitary boulders probably occurred during Vaia, the last extreme storm that hit the Adriatic on the 29th of October 2018. However, the modeled maximum wave height south of Mana during the peak of the storm would be insufficient to move these boulders. Yet local geomorphology probably further influenced the increase in wave height that, in combination with specific geological features, caused displacements of the boulders. There is a shorter fetch affecting Mana Island with respect to the northern Adriatic boulder field in southern Istria. Thus, such an active local erosion of the generally stable eastern Adriatic karstic coast depends on the extreme storms that have a weaker impact in the central than in the northern Adriatic (Korbar et al., 2022).

Reference

Korbar T., Navratil D., Denamiel C., Kordić B., Biolchi S., Vilibić I., Furlani S. (2022): Coarse-Clast Storm Deposit and Solitary Boulders on the Island of Mana (NP Kornati, Central Adriatic, Croatia). Geosciences. 12(10):355. https://doi.org/10.3390/geosciences12100355

Theme 6. Shallow-marine clastic depositional systems

Special Session 6.3. Coastal boulder deposits (CBD) as archives of extreme wave events

Poster presentation

Facies and implications of a coarse-grained lacustrine onshore paleo-tsunamiite: an integrated study of an Upper Miocene bouldery cobble gravel

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Gravelly tsunami event beds are well known from some contemporary shores, but they are far less known from the pre-Quaternary depositional record. Lacustrine examples are particularly exceptional. Here we present multidisciplinary evidence for a lacustrine cobble to boulder gravel deposited as an onshore paleo-tsunamiite and discuss features that help to identify the depositional setting.

The deposit was formed on the rocky shore of a large peninsula within the late Miocene Lake Pannon (Hungary). The lake was several hundred meters deep, and near the study area, it was about 50–80 km wide. The inferred paleo-tsunami deposit includes subangular clasts that are exclusively derived from the underlying Cretaceous sandstone. Imbrication of the bouldery gravel points to landward transport of the clasts, however, a 15-cm-thick lens of cross-bedded sand records an opposing flow direction. The clayey sand matrix contains fossils, i.e. fragmented and articulated mollusc shells, as well as ostracods, that lived on the nearby sandy shoreface and offshore. The facies of the gravel indicates a short-distance transport of clasts typical for an extreme wave event. None of the depositional features e.g. various degree of clast roundness, seaward dipping imbrication, bidirectional transport indicators, clast-supported fabric, large thickness of beds, and lack of grading is either unique to tsunami deposits or excludes storm wave origin. An extreme storm wave origin, however, is discarded, when paleogeography and climate are considered. The combination of matrix-supported fabric, presence of a mixed clayey-sandy matrix in the clast-supported parts, and preservation of articulated mollusc shells, as well as mixture of clasts and fossils from different zones of the shore, identify these beds as paleo-tsunami deposits.

A tsunami could have been related either to an earthquake along nearby normal faults or to large-scale sliding events on the closely located shelf slope. The recognition of these event beds reinforces structural observations on the syn-depositional character of nearby faults, long after the climax of syn-rift tectonics. Thick, boulder-sized onshore paleo-tsunamiites are useful indicators of a paleogeographic situation in which tsunami waves were amplified to produce noticeable beds in the rock record.

Theme 6. Shallow-marine clastic depositional systems

Special Session 6.4. The sedimentology of coastal storms past & present: informing preparedness for climate change

Oral presentation

Evolution and natural recovery of a washover fan, North Adriatic Sea, Italy

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Barrier islands are important landforms that protect the inland, bays, and estuaries from sea storms, and are notable for their rapid morphological changes. Transgressive processes caused by sea-level rise or storms are common modes of barrier evolution. The Marano and Grado Lagoon barrier islands (North Adriatic Sea, Italy) are a significant example of these dynamic environments in a more general human-altered and stabilised context. Between 2012 and 2013, at least two storms hit the westernmost one (Martignano), causing the island breach and the formation of a washover structure (channel and fan). The new formation occurred at the same location as a previous breach, indicating the presence of an erosive hot spot. The aims of the research are to (i) describe the washover morphology and its evolution, (ii) quantify the mode and the timing of the morphological beach recovery, and (iii) verify the existence of sedimentological signatures as diagnostic elements in figuring out the dynamics and evolution following paroxysmal events. Between 2016 and 2021, several Unmanned Aerial Vehicle surveys were performed in the area and compared to previous orthophotos from 2010 and 2014. Sedimentological sampling on significant morphologies was carried out across the entire system. The orthophotos and Digital Surface Models obtained from UAV surveys show that the washover channel was completely filled between 2016 and 2018 (the sediments are up to 0.80 m thick and the volumes accumulated approximately 10147 m^3) before being vegetated in 2021, and the beach was realigned, indicating the achievement of a stable morphological phase. The relict washover fan on the back-barrier area retains its shape: it records at least two storm events, as confirmed by topographical variation in which more than one lobe can be identified, as well as different granulometric suites with reverse grading, highlighting the process dynamics orthogonal to the beach. This case represents an example of monitoring storm effects and subsequent natural recovery processes in a wave dominated environment, demonstrating the importance of episodic events in generating new landforms. Finally, it highlights the benefits of coupling the high-quality data from UAVs and the accurate sedimentological sampling, in order to recognise the effects of natural processes.

Theme 6. Shallow-marine clastic depositional systems

Special Session 6.4. The sedimentology of coastal storms past & present: informing preparedness for climate change

Oral presentation

Polar gravel beaches: recorders of storm climate?

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Sequences of raised beaches are emblematic of many polar coastlines, where they are established archives of relative sea-level, glacio-isostatic adjustment, sea-ice extent, and variations in sediment supply. Here we discuss their potential as recorders of storminess; especially for times of rapid atmospheric warming and deglaciation. Ground-penetrating radar (GPR) data from coarse-grained beach plains in Antarctica (South Shetland Islands) and Arctic (Spitsbergen) demonstrate that gravel ridges unconformably overlie the sediments of the prograding strand plain. This implies that beach-plain progradation and ridge construction reflect different energetic framework conditions: Beach progradation results from fair-weather swash sedimentation, whereas gravel-ridge construction requires intensified wave action and associated elevated wave run-up limits at the shore. The ridge-and-swale morphology of gravel beach-ridge plains is consequently explained by the alternation of storm-dominated sedimentation with periods of more calm (fairweather-) conditions on decadal- to centennial time scales. Ridges remain small on sheltered beaches and the frequency of ridge building is higher, compared to high energy coasts, where ridges are larger and remain active for longer. Ridge-internal stratigraphy strongly depends on wave-runup height during ridge construction. Ridges in high-energy settings are characterized by seaward as well as landward-dipping beds and their architecture is often complex due to several episodes of partial erosion and recovery. Beach ridges in low-energy settings, by contrast, exhibit only seaward-dipping, planar- to sigmoidal-shaped beds. This bedding pattern results from the swash-controlled accumulation of sediment at the beach face. Data show that even older, inactive ridges at higher elevation are subject to reactivation. This challenges the use of elevated beach ridges for sea-level reconstructions and demands a careful investigation of the stratigraphy prior to sampling for age determination purposes. Our results imply that polar gravel beach–ridge plains bear a valuable and yet unread record of past storminess. With this regard, higher temporal resolution and more complete records can be expected from low-energy beach-ridge plains.

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Special Session 6.4. The sedimentology of coastal storms past & present: informing preparedness for climate change

Oral presentation

What paleotempestology can say about the intensity and frequency of future Atlantic Basin tropical cyclones

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Tropical cyclone activity varies spatially as well as temporally throughout the southwest Atlantic and Caribbean regions in modern times as well as in the past. To better understand this variability, we present a high-resolution synthesis of tropical cyclones spanning the last 2000 years in the southwest Atlantic and Caribbean basins as well as Meso and Central America. Various proxies, including stable isotopes on ostracodes, gastropods and speleothems, grain size, percent sand, elemental concentration (Ti, Fe) and red color intensity provide high resolution, multi-proxy of hurricanes. Records from the Bahamas, Cuba, Haiti, Dominican Republic, Puerto Rico, Cariaco Basin, Yucatan peninsula, and Nicaragua show that over the last 2000 years hurricane frequency varied temporally and geographically throughout the region. Atmospheric and oceanic phenomena such as the El Nino Southern Oscillation, the Intertropical Convergence Zone, the North Atlantic Oscillation, as well as the Caribbean Low Level Jet have driven climate and hurricane patterns over the last two millennia. Complex interactions between atmospheric and oceanic phenomena such as NAO, ENSO, ITCZ and CLLJ lead to heterogeneous hurricane patterns temporally and geographically in the region. For example, the relatively northern position of the ITCZ prior to 1300 YBP is coincident with the Hurricane Hyper Activity. After this time, the ITCZ moved southward, coinciding with an overall decrease in hurricane activity in the Western Atlantic. From 400 yr BP to present, the ITCZ has occupied its most Southern Position, coinciding with a relative increase in hurricane activity. However, recent storm records suggest a non-analog relationship with these traditional drivers and a disruption of normalized patterns seen in the past.

Theme 6. Shallow-marine clastic depositional systems

Special Session 6.4. The sedimentology of coastal storms past & present: informing preparedness for climate change

Keynote lecture

Assessing the impact of Hurricane Ian on the Southwest Florida gulf coast to build resilience capacity

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Hurricane Ian, which made landfall in Southwest Florida, USA, on 28 September 2022, severely impacted the coastal geomorphology of the region's barrier islands and mainland beaches. Incoming storm surge, because of its extreme height, resulted in "overwash and inundation regime" impacts, placing the erosional capacity of wave energy well above the substrate. As a result, flood surge resulted in sediment transport via overtopping, overwash fan deposition, and foredune deflation and retrogradation. Ebb surge return, however, caused substantial channelized erosion through foredunes and berms, areas that will not necessarily anneal following fairweather beach aggradation. Ebb-surge erosion resulted in significant structural damage to buildings located just behind the coastal setback. The severity of geomorphic change has posed a challenge for coastal managers, who are considering restoration measures that build and enhance resilience capacity. Through application of ground-penetrating radar (GPR) and UAV-flown LiDAR, we have mapped the morphosedimentary impact of this event, quantified net sediment deposition and erosion by comparing pre- and post-storm digital elevation models (DEMs), explored the resilience value of pre-existing infrastructural measures (e.g., sea walls, dune fortification), and identified persistent ebb-surge erosional hot spots. Narrow barrier segments that experienced most extensive ebb-surge channel formation during Ian commonly show similar features in GPR images to those produced by earlier storms (e.g., channels up to 1.5–2.0 m deep). In contrast, island segments with strandplains exhibited greatest resilience. These qualitative and quantitative observations are being shared with all coastal residents, but particularly with the municipalities of Naples, Fort Myers Beach, and Sanibel, three of the most seriously impacted communities. Ultimately, these data will inform regional hydrodynamic modeling (Delft3D) and morphodynamic modeling (XBEACH) to better anticipate and adapt to future storm impacts.

Theme 6. Shallow-marine clastic depositional systems

Special Session 6.4. The sedimentology of coastal storms past & present: informing preparedness for climate change

Poster presentation

Soft-sediment-induced seafloor relief control on bedforms, Early Triassic Sulphur Mountain Formation (Alberta, Canada)

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Several well-exposed bedding planes along strike in the Lower Triassic Sulphur Mountain Formation (Alberta, Canada) provide a unique opportunity to characterize the influence of soft sediment deformation induced sea floor relief on contemporaneous bedforms. Soft-sediment deformation is characterized by convoluted bedding and silt volcanoes with relief that range from 2–150 centimeters. Small-scale, symmetric 2D wave ripples within enveloping strata suggest deposition in a shallow-water setting, above storm-weather wave base. Based on 3D outcrop model and 250+ paleocurrent measurements, symmetric 2D wave ripples that overlie soft-sediment deformation commonly exhibit (1) wave crest divergence from the average wave crest trend by 2–65°, (2) abruptly transition into small, asymmetric 2.5D combined-flow ripples, or (3) exhibit interference current ripples. These relationships are consistent on at least five bedding planes, and, therefore, suggests a common interaction between fine-grained sediment (i.e., silt to very fine-grained sand), oscillatory currents, and topographic sea floor relief induced by soft-sediment deformation. The variability in wave crest trends and evidence of combined-flow bedforms and interference ripples above these soft-sediment deformation features are interpreted to be the result of flow interaction with the trough and crest of the topographic relief, respectively. The resultant stratigraphy from the interaction between oscillatory currents and topographic relief are likely common in many shallow-water sedimentary systems; however, they are likely under-documented in the ancient sedimentary record due to poor laterally extensive bedding plane preservation in most outcrops.

Theme 6. Shallow-marine clastic depositional systems

Special Session 6.4. The sedimentology of coastal storms past & present: informing preparedness for climate change

Poster presentation

Monitoring of pebble-beach response to typhoons using a drone photogrammetry, Wando, southern coast of Korea

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Unlike beaches in sands, much less attentions have been paid to gravel beaches. This is likely because they have not much experienced coastal erosions and have less considered as recreational area for humans. Beach erosions occur widely when low-frequency storm waves hit the shoreline. High berms are eliminated in response, thereby the slope becoming very gentle. However, we questioned how gravel beaches are responding to typhoon waves. In order to assess typhoon impacts on shingle beaches and their morphodynamic behavior, 3D mapping using a drone and beach profiling survey with a VRS–GPS system have been conducted regularly to capture the typhoons. In addition, grain-size data at 100 stations were obtained from both manual counting and image analysis. Gravel beaches investigated are located in Wando, south coast of Korea, geographically open to the south and, hence, consistent well with typhoon paths. Tidal range in the area is 2.1 m corresponding to mesotidal regime. Topographic survey reveals that former typhoon berms situated at 3 m above MSL were completely removed, and about 4.5 m high berms were newly formed after the typhoon Hinnamnor in 2022. Beach widths were narrowed dramatically almost by 7 m based on mean high water level and the slope became extremely steeped, forming 45^0. The morphologic response of the beaches to typhoons varied spatially. Along the eastern zone consisting of cobbles to boulders, new berms were formed and rather deposition occurs, whereas, from the center to western zone, pebble-sized beaches were eroded away. It is evident that sediment sizes may play a vital role in morphodynamic response of the shingle beach. Interesting feature is rapid recovery rate. Volume calculations have shown ca.13% loss and 4% gain in total volume in three weeks. Mean sizes for the gravels range from -8.5 to -3.7 phi. Little changes were observed, regardless of typhoons. The typhoon berm at 4.5 m is comparable to high-ranked typhoon Bolaven in 2012. However, another highest berm at 8 to 11 m in the area occurs. This highest gravel berm is challenging. This study showcases how shingle beach is morphodynamic responding to mild typhoons.

Theme 6. Shallow-marine clastic depositional systems

Special Session 6.5. Spatial and temporal variability in coastal to shelf environments

Oral presentation

Saltmarshes in a backbarrier lagoon: sediment source and variability

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In backbarrier lagoons, saltmarshes represent a depositional sub-environment with peculiar characteristics and management demands. With saltmarshes covering approximately 760 ha, the Grado and Marano Lagoon is an important wetland in the Northern Adriatic (Italy). Here, the extent of saltmarshes has decreased over the last fifty years due to a combination of natural and anthropogenic factors. Two short cores of sediment were collected from each of the twelve sample sites, which were chosen to represent different saltmarsh environments. Their stratigraphic description was combined with the recent morphological evolution (1910–2010), as determined by cartography, aerial photos, and topographic surveys. The facies description has been improved by using grain size and mineralogical-compositional data determined by a laser diffraction particle size analyser and the powder diffraction method, respectively. In the inner part of the lagoon, silt content is dominant even in cores situated in different morphological contexts, such as isolated and channel-fringing saltmarshes or abandoned fish farms. The facies transition from the tidal flat sub-environment to the saltmarsh sub-environment is frequently discernible and is marked by small grain size differences, both fining and coarsening upward. These different trends attest to the role of local changes in environmental and hydrodynamic conditions, as well as human action. Sand is the main component in the backbarrier saltmarshes, where the grain size variability along the core is evident due to the mixing of tidal and coastal processes. The mineralogical composition is geographically distributed in accordance with the morphology and hydrodynamics of the lagoon. The highest carbonate concentrations were only found in saltmarshes near or directly connected to tidal inlets, thus emphasising the importance of the external sedimentary source (Isonzo and Tagliamento rivers), with calcite playing a discriminant role. Our findings and interpretations contribute to a better understanding of the depositional model of saltmarshes in a back-barrier lagoon, particularly in different erosive or depositional contexts and with significant human interferences.

Theme 6. Shallow-marine clastic depositional systems

Special Session 6.5. Spatial and temporal variability in coastal to shelf environments

Oral presentation

Distribution pattern and controls of biosedimentary facies in backbarrier tidal flats of the central Wadden Sea (North Sea)

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The Wadden Sea, extending from the Netherlands over Germany to Denmark is one of the the largest coherent tidal flat system in the world and part of the Unesco World heritage. It is unique in its combination of high sediment- and morpho-dynamics and its role as a key hub between northern and southern hemisphere for migratory birds. Biodiversity on a world wide scale is therefore reliant on this site. Furthermore, the extensive tidal flats provide the opportunity to document biosedimentary facies of a coastal to shallow marine environment and to observe its changes over time due to climate change and sea-level rise. The understanding of the depositional processes in this partly natural and partly anthropogenic landscape due to coastal protection measurements is also important for the targeted search for archaeological remains. We mapped the biosedimentary facies of a large backbarrier tidal flat system over a decade in the field covering four tidal basins with an area of 144 km^2. The spatial distribution of biosedimentary facies shows a complex pattern on a local scale, which superimposes the shore-normal energy gradient on a regional scale. The main controlling factors are hydrodynamic energy, the relative position to partly strongly shifting tidal channels, the duration of emergence, organism–sediment interaction and the presence of invasive species. Due to strongly fluctuating abundances of benthic organisms, the lateral extension of biosedimentary facies may differ significantly over the years. However, the grain size distribution reflects a more long-term equilibrium with the hydrodynamics of this coastal region. Additionally, we have documented a system shift of biogenic structures caused by the invasion of a non-native species, which functions as an ecosystem engineering species. Since we have focussed on tracemaking organisms, i.e., polychaetes and shell-bearing molluscs combined with abiotic parameters, the biosedimentary facies pattern of our study can be transferred into multidimensional facies analyses of sedimentary rocks deposited along ancient tidal coasts.

Theme 6. Shallow-marine clastic depositional systems

Special Session 6.5. Spatial and temporal variability in coastal to shelf environments

Oral presentation

Cautions to be taken when analysing cyclicity in mixed siliciclastic–carbonate coastal successions

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Mixed siliciclastic–carbonate coastal successions are frequently interpreted as a result of deposition during high frequency changes in relative sea-level. However, analysing cyclicity is challenging in successions controlled by climate and tectonics. This is the case of the Kimmeridgian–Tithonian Villar del Arzobispo Fm, a mixed siliciclastic–carbonate unit cropping out in the W Maestrazgo and South-Iberian extensional basins (SE Spain). Its deposition was largely affected by synsedimentary faults that controlled its thickness, which is greater to the SE, towards the Tethys Sea (up to 1350 m), than to the NW (up to 450 m). In this work, 8 stratigraphic sections and several laterally continuous outcrops are analysed, from NW to SE, to evaluate the suitability of this unit for performing cyclicity analysis. In all sections, the unit shows, at its lower part, shallow marine limestone that change towards its upper part to essentially siliciclastic fluvial, aeolian and deltaic deposits, following a regressive trend. These siliciclastic deposits are interbedded upwards with tidal and shallow marine limestone, as a result of a marine transgression. As expected, tidal and shallow marine limestone beds are more abundant and thicker to the SE. However, limestone beds or carbonate–siliciclastic cycles are not laterally correlatable, due to two main reasons: 1) the occurrence of synsedimentary faults, which significantly change the thickness of the unit, prevents the correlation of carbonate beds across them; 2) the unit was deposited under a seasonal and monsoonal-type climate, in which fluvial channels transported, during rainy seasons, large volumes of siliciclastic sediments that were deposited in mouth bars flowing into tidal and shallow marine carbonate areas. During these periods, mouth bars were also abandoned, shifting laterally after successive floods. As a result, the unit shows abundant stochastic lateral and vertical facies changes between tidal and shallow marine limestone and fluvial and mouth bar siliciclastic deposits, preventing to delimit and correlate cycles even at distances of less than 500 m. Thus, this study remarks how the great facies and thickness variability displayed by coastal successions controlled by tectonics and seasonal climates prevent performing cyclicity analysis.

Theme 6. Shallow-marine clastic depositional systems

Special Session 6.5. Spatial and temporal variability in coastal to shelf environments

Oral presentation

Gone digital – utilizing drone imaging to characterize siltstone-dominated deposits: implications for quantifying meter-scale sedimentary heterogeneity

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Fine-grained deposits are known to have significant vertical and lateral heterogeneity at various scales. In the subsurface, cores analysis remains the highest resolution dataset to characterize and understand these deposits. However, cores only give insight at ~10 cm width and are spaced 10's to 100's of kilometers apart making it challenging to upscale to architectural variations at the meter- or kilometer-scale. To compensate this scaling issue, outcrop analogues are the best available dataset to understand large-scale characteristics. Here we investigate a set of cliff faces (300 m thick by 1000 meter wide) of the siltstone-dominated, lower Triassic Sulphur Mountain Formation (Alberta, Canada) to document meter- to kilometer-scale vertical and lateral distribution of facies using drone photography. This, aided with a well-exposed creek section to document detailed facies, facies stacking, depositional environments, therefore provides a multi-scale approach to characterizing a siltstone-dominated succession. Using high-resolution, drone photomosaics and Pix4D, a digital facies scheme was used to quantify the vertical (thickness) and lateral (width) heterogeneity distribution of facies in the cliff face and relate back to the well-exposed creek sections. Based on facies distribution measurements and depositional processes, the Sulphur Mountain Formation consist of an overall shallowing upward sequence. From stratigraphic bottom to top stratal units comprise (1) very thinly bedded, isolated, pinstriped laminated siltstone; (2) thin-bedded, heterolithics intercalated with medium- to thickly bedded, massive siltstone; (3) scour-filled, massive siltstone intercalated with thin-bedded heterolithics; and (4) coarsening-upward packages (i.e., parasequences).

The observed vertical and lateral variability in the Sulphur Mountain Formation provides insight into changing depositional environments and dynamic processes that affect sediment distribution in a shallow water (<100 m water depth) setting, resulting in a highly heterogeneous siltstone succession. This study also provides a quantitative approach on drone photography, which can be implement in steep outcrops faces as they commensurate with conventional stratigraphic logging techniques.

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Special Session 6.5. Spatial and temporal variability in coastal to shelf environments

Oral presentation

Three-times transgressive sedimentation from the Late Quaternary of Baeksu tidal flat, southwest coast of Korea

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Many chronostratigraphic studies for the late Quaternary deposits have been successfully conducted by applying optically stimulated luminescence (OSL) dating method (up to 500 ka age limit), which overcomes the detection limit of ^{14}C-AMS (up to 40 ka limit). High-resolution stratigraphic framework (5th order cycle) of modern analogues from fluvial to shelf area enabled to elucidate coastal evolution associated with short-term sea-level fluctuations. Previous works showed that fourth-order regressive facies are deposited during the LST, followed by the same order transgressive facies deposited in the early TST. The cycle was often interrupted by the fifth-order regressive deposits. Along the west coast of Korea, twice of fourth-order regressive and transgressive sedimentation have been recorded, the cycle being bounded by oxidized layers, interpreted previously as fluvial regressive deposits. However, we re-examine the oxidized regressive systems tract by using geochemical and micropaleontological proxies. Three drilled-cores taken along the cross-transect of tidal flats were selected for multi-disciplinary analysis. The Baeksu tidal flats can be divided into thirty-nine facies, these being grouped into five depositional units: 1) basal fluvial gravels, 2) mudflat/saltmarsh (MIS 5e), 3) gravelly spit/saltmarsh/mudflat (MIS 5a/b), 4) gravelly spit/mudflat (MIS 3), and 5) tidal flat/intertidal shoreface/sandy beach deposits (Holocene) in ascending order. Two fourth-order sequences were observed about time scale of 100,000 yrs. and the internal fifth-order sequence developed with times scale of 40,000 yrs., which includes retrograding gravelly spit–mudflat interpreted newly as the high-frequency cycle of TST in this study. Conclusively, three transgressive depositions occur as a different type and sequential order. Regressive deposits were formed only during the HST in the late Holocene. Regressive phase is likely represented only by subaerial exposure of former transgressive deposits, being deeply oxidized in some places. Contrary to three transgressive deposits, little preservation for the regression phase are due possibly to the absence of major rivers, capable of supplying the large quantity of sediments. This study may shed light on high-frequency sequence analysis implemented by OSL dates.

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Special Session 6.5. Spatial and temporal variability in coastal to shelf environments

Oral presentation

A standardised seabed geomorphology classification scheme to support mapping and interpretation of submerged environments

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Maps of seabed geomorphology provide foundational information for a broad range of marine applications including depositional environment and facies interpretation. To be most effective, geomorphic characterisation of the seabed requires standardised, multi-scalar and interjurisdictional approaches that can be applied locally, regionally and internationally using the best available data. An ongoing collaboration between geoscience agencies in the United Kingdom (BGS), Norway (GSN), Ireland (GSI and UCC) and Australia (GA) has focused on developing a new standardised two-part mapping approach to meet this need. Part 1 was published as an open access glossary that includes an illustrated list of terms and definitions that primarily draw on the International Hydrographic Organization standard (Dove et al., 2020). Morphology maps are created by applying Part 1 Morphological terms to bathymetry data, implemented in a GIS environment. Part 2 classifies mapped shapes with their geomorphic interpretation; geomorphic unit terms are structured within 5 geomorphic Settings (Fluvial, Coastal, Marine, Glacial, Hard Rock) and 6 Process (Current-induced, Biogenic, Mass movement, Fluid Flow, Karstic, Anthropogenic) categories. Consistent with Part 1, Part 2 terms are primarily sourced from established literature. The application of Part 2 requires further seabed data and/or contextual information and expert judgement, and is intended to constrain the uncertainty that is inherent to subsurface facies interpretation and prediction to this step. A draft version of Part 2 was presented at the IAG's International Seafloor Geomorphology Conference in Malta (July 2022). Feedback from that workshop and from the broader community was integrated into a revised version of the scheme, to be released in March 2023. We will demonstrate the application of this method to several worked examples from coasts, continental shelves and the deep marine, and thereby demonstrate the utility of the two-part approach for mapping the distribution of sedimentary facies that form in these diverse marine environments.

Reference

Dove et al. (2020): https://zenodo.org/record/4071940

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Special Session 6.5. Spatial and temporal variability in coastal to shelf environments

Oral presentation

Short-term variability of a forced regressive shoreline: using remote-sensing to quantify coastal movement along the Gulf of Carpentaria

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The long-term development of modern and ancient coastal distributive fluvial systems (DFSs) during periods of relative sea-level highstand, fall, and lowstand are often associated with net-progradational shorelines. However, modern marginal-marine systems demonstrate considerable spatial and temporal along-strike variability, strongly impacting the architecture of the preserved strata in the rock record. Australia's largest coastal DFSs along the south eastern shore of the Gulf of Carpentaria have prograded (down-dip) up to 20 km over the mid- to late Holocene, however, their complex architecture captures temporal and spatial variations in dominant coastal processes and shoreline trajectories. A new continental dataset from Geoscience Australia's Digital Earth Australia (DEA Coastlines) provides mean annual shoreline positions for 32 years (1988–2019) and provides a great opportunity to investigate short-term variations in coastal trajectory for comparison with the systems Holocene evolution. DEA Coastlines reveals that only 54% of the modern coastline segment studied has net-prograded between 1988 and 2019, whereas 46% was eroded. Much of this change has occurred at up to ±2 m pa. Results also display a multi-year cyclical alternation of periods dominated by coastal progradation versus periods dominated by coastal erosion, which correlates poorly with both total precipitation (used as a proxy for sediment supply) and the Southern Oscillation Index. The dynamics of the coastline between 1988 and 2019 instead appear to have responded more directly to the complex interactions between fluvial, wave reworking, longshore currents, and tidal processes. Our results also show that hinges between areas of progradation and retrogradation are dynamic and migrate depending on the temporal scale considered. The complex nature of the resulting stratigraphic surfaces, their intricate lateral correlation, the architecture of the preserved strata, and the distribution of heterogeneities in the sedimentary record associated with the documented short-term coastal dynamics can thus preclude longer-term basin reconstructions and sequence stratigraphic analysis, blurred by the amalgamation of different timescales at which each of the processes occur, depending on the time interval considered.

Theme 6. Shallow-marine clastic depositional systems

Special Session 6.5. Spatial and temporal variability in coastal to shelf environments

Poster presentation

Sedimentation on a channelized, open-coast macrotidal flat of the mid-western coast of korea

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Sedimentation on the open-coast tidal flats is known to be controlled by seasonal variations in the intensity of onshore winds and waves. Still, sedimentation and facies distribution in the channelized open-coast tidal flats are less well understood, partly due to the lack of long-term field observations. The present study investigates the spatiotemporal variability of sedimentation on the Yeochari tidal flats, the most extensive open-coast tidal flats on the west coast of Korea, to understand governing factors that drive the variability and construct a new facies model for open-coast tidal flats. In winter, when north-to-northwesterly winds prevail, sand flats in the western part of the Yeochari tidal flats expand while those in the eastern part remain unchanged. Despite the enhanced wave activity, however, mud flats broaden in the eastern region due to the presence of biofilm that promotes mud deposition. Mud deposition is also notable in the flanks of tidal channels in the lower intertidal zone, reflecting tidal sedimentation during calm weather in winter. In spring, sustained but subdued wave activity leads to coarsening in the upper intertidal zone and fining in the middle to lower intertidal zone, indicating seaward transport of fine-grained sediments. In summer, tidal flats, particularly in the eastern part, become coarser-grained due to the impingement of waves generated by south to southeasterly winds. Frequent heavy rainfalls facilitate channel migration by inducing an ebb dominance with increased surface runoff. Notable mud deposition occurs at the flank of tidal channels in the lower intertidal zone during the calm period. In fall, tidal flats, especially in the western part, experience erosion to become coarser-grained due to increased wave activity, resulting in a widening of the mixed flats. Highly channelized morphology with seasonal storm waves and autocyclic channel migration accentuated by heavy rainfalls promote spatiotemporally heterolithic deposits in the middle to lower intertidal zone, which does not fit the existing tidal-flat facies model and warrant further research.

Theme 6. Shallow-marine clastic depositional systems

Special Session 6.5. Spatial and temporal variability in coastal to shelf environments

Poster presentation

Subaqueous dune asymmetry analysis reveals separation of a linear tidal sand ridge off the Garolim Bay mouth, midwestern macrotidal coast of Korea

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Located about 5 km off the Garolim Bay mouth, central west coast of Korea, a large tidal sand ridge is, morphologically, 30–35 km long and 1.5–5 km wide with a relief of 10–50 m. Over the past two decades, dredging and sand mining have been conducted. The sand ridge is inevitably anticipated to respond to the changing conditions caused by the human activities. In this context, the elongate ridge was investigated to determine the extent to which the morphology of the ridge has changed, and to track transport pathways of sediments inferred from the analysis of bedform asymmetry. Grain-size analyses of surface sediments showed that medium sands dominate along the ridge crest, whereas both flanks are composed of coarse sand. Pebbles or shelly gravels are restricted to both adjacent troughs. The comparison of bathymetric maps shows that the sand ridge shrank significantly since 1970. The crest of the ridge moved about 0.9–1.5 km eastward, whereas the ridge base remained unchanged. From 2009 to 2015, the middle sector of the ridge experienced about 6.7% of sediment loss by volume. At the same time, the ridge height was lowered by about 5 m. However, the morphologic change of the ridge is not likely linked to sand mining and dredging. The asymmetry analysis of subaqueous dunes revealed a dominant sediment transport direction towards the east or northeast, major tidal currents being flood-dominated in the mid-sector. However, in the northern sector, the bedforms are ebb-dominated, indicating a counter-clockwise circulation pattern. There are therefore two different circulation patterns splitting in the bedload divergence zone, potentially leading to a separation of a linear sand ridge. This fact may shed some lights on understanding the morphological behaviour and development of the ridge.

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Special Session 6.5. Spatial and temporal variability in coastal to shelf environments

Poster presentation

Sedimentology and stratigraphic variability of uplifted Late Quaternary shoreline deposits along the southern margin of the Corinth Rift, Greece

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The southeastern footwall of the active basin-bounding normal faults of the Gulf of Corinth, Greece, comprises a series of uplifted late Quaternary syn-rift shoreline deposits, preserved as 'staircase' marine terraces. This study documents the sedimentology and stratigraphic variability of the Marine Isotope Stage (MIS) 7 deposits (ca. 190–240 kyr) through integration of field-based sedimentological analysis and interpretation of digital outcrop models. The MIS7 deposits unconformably overlie Plio–Pleistocene deep-water deposits, their base is represented by a wave-ravinement surface marked by coarse-grained shoreface lags (S0). Facies show a range of environments from open-marine mixed siliciclastic–carbonate, wave/storm-dominated shorelines, and clastic deltaic deposition. A regional erosive contact (S1) separates MIS7 deposits into two units: (i) a lower unit, that displays aggradation passing into progradation, and (ii) an upper unit, of prograding wedge-shaped geometries with seaward downlap onto S1 and pass laterally into flat-lying interdistributary deposits. The facies variation between the lower and upper unit, from bioturbated shoreface and preservation of carbonate factories to calci–siliciclastic deltaic deposition, suggest a change from supply-depleted to a relatively high sediment-supplied shoreline. U/Th dating of corals from the lower unit gives an absolute age of ca. 200 ka, age-equivalent to MIS7e interglacial highstand. The supply-depleted interpretation of the lower unit indicates that accommodation outpaced sediment supply, as forming during the initial phase of MIS7e deposition. The upper unit wedge deposits show a basinward shift of coastal onlap forming two terrace levels, thus recording a subsequent descending paleo-shoreline trajectory and forced-regressive interstadial deposition. This pattern is not observed along the interdistributary deposits that occur as a single terrace limited basinward by a younger steep outer notch. MIS7 deposits, therefore, show two depositional patterns (i) aggradation–progradation–degradation, along the main supply fairways, and (ii) aggradation–degradation, along low-supply zones. Our study documents the variability of coastal sequences formed under differential uplift rates at the same climatic conditions

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Special Session 6.5. Spatial and temporal variability in coastal to shelf environments

Poster presentation

Variability in process regime in the Lower Cretaceous Pilmatué marginal-marine system (Neuquén Basin, Argentina)

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Marginal-marine environments show a large number of physicochemical processes (e.g., fluvial currents, tides, waves, salinity changes) that operate at different temporal and spatial scales. To better understand this complexity this study focused on the succession of the Pilmatué Member (Agrio Formation, Lower Cretaceous, Neuquén Basin, Argentina) with the aim to unravel the sedimentary processes, facies associations and accumulation of this marginal marine system. The succession was studied with log descriptions and facies analysis using a total of 150 m of cores from two distinct wells.The succession is siliciclastic dominated, arranged in a general coarsening upward trend and consists of five facies associations interpreted as: delta plain, distributary channels, mouth bar complex, distal-delta front and transgressive deposits. The distal-delta front contains very-fine sandstones interbedded with bioturbated mudstones with flaser to horizontal lamination. The mouth-bar complex involves a variety of carbonaceous-rich very-fine sandstones with horizontal lamination or structureless. The distributary channels show erosional bases and consist of carbonaceous-rich very-fine sandstones with cross bedding, asymmetrical ripples, intraclast mudstones and soft sediment deformation. The delta plain includes mudstones and very-fine sandstones with asymmetric ripples, root marks and high bioturbation index. Finally, the transgressive deposits consist of bioclastic sandstones. The succession was interpreted as a deltaic system recording a progradational shallowing-upward trend and changes in the depositional processes from wave-dominated, tide-influenced distal-delta front deposits to proximal fluvial-dominated delta-plain deposits. Understanding spatial-temporal variability in process regime recorded in similar marginal-marine successions requires a bed by bed detailed description, which, in this study, was allowed by the superb quality of the Pilmatué Member cores. This study demonstrates that even within relative thin packages (10–15 m) the system does not necessarily have to be “one process dominated” but show a variability of process as the system shifts between proximal to distal environments.

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Poster presentation

Natural vs. Anthropic signature in a coastal evolution. The case study of the Domitia littoral (southern Italy)

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The present geomorphology of the Volturno River (VR) delta system and related strandplain (northern Campania, southern Italy) is largely a product of complex, long-lived relationships between geological evolution and human impacts. To assess the main drivers of the changed landscape in the last centuries, a multidisciplinary study was carried out by combining geological (stratigraphic well logs) and historical (cartographic sources) data. The plain was characterized by an intense volcanic activity since the Late Pleistocene. A 39 Ky explosive eruption emplaced the Campania Grey Tuff deposits (CGT) that covered the whole plain with a thick, laterally continuous, volcaniclastic unit. The reconstructed upper surface of the CGT highlights a wide valley characterized by a complex river network flowing on the plain during the Last Glacial Maximum sea level drop. Above the CGT surface, in correspondence of the reconstructed palaeo-rivers, fluvial-channel deposits occur; upward and laterally they alternate with alluvial plain lithofacies associations. Towards the current deltaic and coastal plain, swamp sequences can be recognized, occurring in a back-stepping stacking toward the inner plain. Seawards and upwards these lithofacies pass to lagoonal facies. A beach–dune system documents the persistence, in the present position, of a transgressive-barrier. Since 6.5 ka a coastal progradation phase allowed the formation of the present-day delta system and the alluvial plain of the VR. The reconstructed palaeodrainage network evidences that the position of the river courses is very similar to the recent one shown in historical maps that represent the geography of the area prior to the reclamation works of the last 2 centuries; the latter resulted in an intensive land transformation and the loss of most coastal wetland coupled with coastal erosion. The study therefore showed that while the landscape evolution during the Late Pleistocene–Holocene was mainly sea level driven, the transformation during the last millennium was largely due to human interventions, both direct (reclamation, development of drainage network, land use changes) and their indirect consequences (increasing exposure to storm/flood events, severe coastal erosion, land subsidence).

Theme 6. Shallow-marine clastic depositional systems

General Session

Keynote lecture

A little-known class of marine, high-angle, sub-wave base sandy clinoform beds – a possible motif for shallow marine, intracratonic rifting

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Outcrops of coarse-grained, high-angle clinoform sets are impressive and eye-catching. They are in most cases interpreted as representing Gilbert-type deltas. However, superficially similar clinoform sets are also known from marine, sub-wave base settings. They were formed during storms mainly by downwelling, seaward-directed currents which transported sand from the coastal area and shoreface across the shelf in suspension or as bedload to be deposited as clinoform sets. They are in many cases associated with rift events, where new accommodation space was created together with an increased supply of coarse-grained sediment. This type of marine sub-wave base clinoform sets are characteristic features in the Jurassic of East Greenland where a protracted rift phase was initiated in the Bajocian and culminated in the Tithonian. Each rift event was accompanied by formation of clinoform sets which prograded seawards away from the cratonic coastline in water depths below wave base. These sets represent a little-known, commonly misinterpreted sedimentary system and may serve as motifs for rifting in shallow marine areas elsewhere in the geological record. Similar sets have been recorded in outcrop from the Mediterranean, and elsewhere and are probably much more common than hitherto realized.

Theme 6. Shallow-marine clastic depositional systems

General Session

Oral presentation

Introduction to a new clastic, wave-dominated shoreline system in southern Montana (USA)

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To study stratigraphy-related, sub-seismic scale heterogeneities, we searched for an accessible wave-dominated shoreline system to sample for characterisation of petrophysical properties. In this context, we introduce a new analogue of clastic, wave-dominated shoreline system embedded in the Judith River Formation (Campanian, Upper Cretaceous). In southern Montana, this formation outcrops as a succession of three stacked sequences of shallow marine deposits. We have studied a section in a North-to-South oriented cliff next to the town of Bridger (Montana, USA). The lowermost sequence is a wave-dominated system, approximately 50 m thick, and with a preliminar paleoshoreline orientation pseudo-parallel to the outcrop. Several types of field data have been collected, including five stratigraphic logs, photogrammetry imagery and panoramic imagery using a unmanned aerial vehicle (UAV), rock samples, and fine material for biostratigraphical analysis. Based on the field data, we have carried out an architectural and sedimentological characterisation of the system. Five different facies have been defined and linked to depositional environments ranging from offshore to shoreface. The main characteristics of the system include limited variation of grain size distribution, anecdotic presence of bioturbation, and very limited cementation. The photogrammetry imagery has been processed using the Metashape Agisoft software to build two 3D models covering 1.2 km along the cliff. These models have been used to interpret in detail the lateral thickness variation of the facies. Panoramic images have been used to extend the interpretation by 2.5 km. The transition between facies is gradual and limited erosional processes have been observed. The rock samples have been used to analyse the lateral and vertical variation of petrophysical properties (density, P-velocity, and S-velocity). This new analogue for clastic wave-dominated systems enables observations at different scales, ranging from thin section to seismic interpretation. It also stands out due to its lateral continuity – up to 4 km of continuous and almost undisturbed section, accessibility – located less than a kilometre to the west of Bridger, and stratigraphical completeness – sediments from offshore to shoreface.

Theme 6. Shallow-marine clastic depositional systems

General Session

Oral presentation

Seyhan–Ceyhan Delta complex and the Plio-Quaternary evolution of the Adana Basin, Eastern Mediterranean Sea, Türkiye

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The Seyhan–Ceyhan Delta complex (SCDC) is a thick sedimentary prism at the northern margin of the Adana Basin which started to open in the Late Oligocene–Early Miocene time dependent on the subduction of the African Plate under the Anatolian block in the eastern Mediterranean Sea. The host basin covering the SCDC is bounded by the Misis Mountains (Misis uplift) in the east, the Ecemiş Fault Zone in the west, and the Cyprus Beşparmak Mountains in the south. The thickness of the infill of the Adana basin exceeds 6000 meters, and it seems that the deposition was controlled by synsedimentary tectonism continuously. The basin-fill can be divided into two parts as *lower* (Oligocene–Miocene) and *upper* (Pliocene–Quaternary) by the Messinian evaporites. The upper part of the fill is represented mainly by the SCDC. This study focuses on the Quaternary evolution of the basin fill using various subsurface data.

Six long wells and seven seismic profiles on marine and subaerial parts of the SCDC are the main data of the study. Thanks to them the stratigraphy of the basin fill could be visible, and we could detect the development of the deltaic deposition. One of the striking results of the subsurface data is the presence of lenticular evaporates; possible evidence for Messinian crisis within the basin fill. These evaporites were key horizons for the stratigraphy and they also created some diapirs deforming the sequences.

The overlying upper part (ca 2200 m thick) is divided into Avdan Fm of early Pliocene and Kuranşa Fm of Pliocene–Pleistocene according to marine fossil data. The sedimentary architecture of the upper unit looks like a prism thickening seaward reaching up to six times. The Avdan Formation is composed of coarse-grained clastic and marine mudstones. To the interpretation, it represents Zanklean transgression following the Messinian crisis. The Kuranşa Formation, which was dated as Pliocene–Pleistocene comprises red-colored terrestrial sediments deposited near the basement and marine sediments toward the south and offshore. Our investigation results revealed that both the Pliocene and Pleistocene part of the Kuranşa Formation includes two separate delta developments respectively, therefore it is considered as a delta complex comprising four delta sequences. The present, active Seyhan–Ceyhan Delta has begun to progress over this complex (the SCDC), following the Holocene transgression since the last 6 ka.

Theme 6. Shallow-marine clastic depositional systems

General Session

Oral presentation

Investigation of a deltaic thermal water reservoir formation in the Zala region (SW Hungary) to estimate the "geothermal reinjection potential"

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The preliminary geothermal potential of the Zala region (SW Hungary) is assessed to be good, however, the sustainable thermal water use would require a significant increase in the reinjected proportion of the used thermal water. One of the main thermal water-bearing aquifers is the Neogene (so-called Pannonian) deltaic formation. These siliciclastic rocks are often sources of injection-related problems which hinder low-pressure reinjection and thus sustainability. In this research, following the workflow of previous studies (Markó et al., 2021) we investigate the potential problem sources ranging from the regional hydraulics through the reservoir scale parameters until the local clogging processes. Predicting the issues makes it possible to mitigate them, and it contributes to a "reinjection potential" assessment which can be part of the geothermal potential estimation. In the current study, we specifically consider the reservoir properties by determining the location of the best reservoir bodies. This joint project in cooperation with MOL Plc. is motivated by the intention of the oil businesses to move towards green energy following the Green Transition EU strategy. The existing datasets (e.g. seismic and well-logs) gained during the hydrocarbon exploration offer enormous potential for geothermal utilisation. Therefore, we interpreted 3D seismic volumes and calculated the RMS amplitude of specific horizons to detect the sand-prone volumes as well as we combined the results with well-logs. The analysis helps to predict where to drill the next reinjection well as well as to evaluate the potential of the existing hydrocarbon wells.

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Reference

Markó, Á., Mádl-Szőnyi, J. & Brehme, M. (2021). Injection related issues of a doublet system in a sandstone aquifer-A generalized concept to understand and avoid problem sources in geothermal systems. Geothermics, 97, 102234.

Theme 6. Shallow-marine clastic depositional systems

General Session

Oral presentation

Vertical and lateral facies correlation of Opalinus Clay in central northern Switzerland: towards an integrative depositional model

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The Opalinus Clay, a silty to sandy claystone formation, is known in Switzerland as being the selected host rock for deep geological disposal of radioactive waste. Since the 1990's, various geotechnical, mineralogical and sedimentological studies addressed the Opalinus Clay have been studied within the framework of the Nagra (National Cooperative for the Disposal of Radioactive Waste) deep drilling campaigns and the Mont Terri Project (international research program dedicated to the investigation of claystone). The Opalinus Clay succession accumulated from the Late Toarcian to Early Aalenian in an epicontinental sea covering central Europe. The Opalinus Clay appears relatively homogeneous at large-scale compared to other Mesozoic formations in northern Switzerland. At higher spatial resolution, however, sedimentological facies varies clearly. Besides m-scale lithofacies variations, considerable lithological variability occurs at dm- to cm-scale. The facies diversity is primary attributed to regional differences in depositional, environmental and diagenetic conditions. The aim of the present study is to understand the lateral and vertical facies variability within the Opalinus Clay in Central Northern Switzerland using petrographical, mineralogical and geochemical data. Accurate petrographic descriptions are an important prerequisite to many geotechnical and diffusion (geochemical) studies and the predictive modelling of petrophysical properties. Petrographic descriptions are performed on nine drill cores using a revised subfacies classification scheme based on texture (grain-size, bedding, fabric and colour) and composition (nature and mineralogy of components). Additionally, X-ray diffraction (XRD) analyses of the different subfacies were performed at a resolution of 5 cm along the nine cores and X-ray fluorescence (XRF) logging were also obtained at a logging resolution of 5 cm to identify lateral and vertical facies variability. Small-scaled vertical facies variations, as well as marker horizons are identified and can be correlated at regional scale. The complex lateral and vertical facies variability requires the revision and definition of new depositional models for the Opalinus Clay at basin and regional scale.

Theme 6. Shallow-marine clastic depositional systems

General Session

Poster presentation

Stratigraphic architecture of the Pliocene extensional Valdelsa Basin in the hinterland of the Northern Apennines (Italy): data from the CARG Project

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The Valdelsa Basin is one of the most representative and large basin of the hinterland of the Northern Apennines that developed during post-orogenic extensional tectonics since Middle–Late Miocene until the Late Pliocene–Early Pleistocene. Crustal extension was linked to the opening of the back-arc Tyrrhenian Sea followed to the eastward migration of the Northern Apennines orogenic phase. The Pliocene marine transgressive event followed to the Messinian post-evaporitic continental–paralic phase ("lago-mare" facies), was accompanied by high subsidence-rate related to the formation of extensional depressions leading to the development of thick (up to 1000 m) and complex marine successions. Deposits are represented by inner shelf and deltaic sandstones, clays and conglomerates. Bioclastic limestones are also present and indicate the settlement of temperate–warm carbonate factories, Late Pliocene in age. Strata are organized in a sequential-stratigraphic architecture showing multiple transgression–regression cycles controlled by tectonics and climate forcings, acting on accommodation space and sediment supply, which led to repeated alternations of thick shallow-marine and fluvio-deltaic sequences. Part of the Pliocene infilling of the basin developed during the "mid-Pliocene Warm Period" (between 2.9 and 3.3 Ma, Piacenzian), with progressive transgressions on to the basin margins, up to the general regression culminated during the latest Pliocene–earliest Pleistocene with the alternation of shallow-marine, to deltaic facies, up to the alluvial systems closing the marine sedimentation. Here we present data from the ongoing CARG Project-286 (part of the Italian Geological Mapping Project), where detailed field mapping, high-resolution biostratigraphy and facies analysis on the filling successions of the Valdelsa Basin are allowing the reconstruction of a new stratigraphic model, which shows the complex relationships between tectonics, climate/eustasy and sedimentation in a developing extensional basin. Finally, with the obtained data set it will be possible to put forward a paleogeographic–paleoenvironmental evolutive model for the Valdelsa Basin during the "mid-Pliocene", which represents a very important climate phase for all the Mediterranean marine depositional systems.

Theme 7. Deep-marine clastic depositional systems

General Session

Oral presentation

Architectural analysis of the Paine C Channel System, Cerro Toro Formation, Chile

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Understanding variations in the sedimentary processes and resulting stratigraphic architecture in submarine channel systems is essential for characterising sedimentary facies distribution on submarine slopes. In the Santonian to Campanian Cerro Toro Formation, southern Chile, a coarse-grained slope channel system, informally known as the Lago Sofia Member, developed in a structurally controlled environment, with complex and poorly established relationships with the surrounding mud-rich heterolithic deposits. A detailed architectural analysis of the most continuous and best-exposed channel system in the Lago Sofia Member, the Paine C, provides insights on lateral facies transitions from channel axis to margin, stacked in a multi-phase sequence of events marked by abrupt changes in facies, facies associations, and architecture. The Paine C channel system is incised into siltstones and claystones interbedded with thin-bedded very fine sandstone, interpreted to be either channel-related overbank or unrelated background deposits. The coarse-grained deposits are divided into a lower conglomeratic unit and an upper sand-rich unit. The lower conglomeratic unit can be further subdivided into three phases: 1) highly depositional and/or aggradational, dominated by thick and laterally continuous beds of clast- to matrix-supported conglomerate, herein named transitional event deposits; 2) an intermediate phase, including deposits similar to those dominant in phase 1 but also containing abundant clast-supported conglomerates and lenticular sandstones; and 3) a bypass-dominated phase, which records an architectural change into a highly amalgamated ca. 45-m-thick package composed purely of lenticular clast-supported conglomerates with local lenticular sandstones. Between the conglomeratic phases, a metre-scale package composed of interbedded thin- to medium-bedded sandstone and mudstone deposits is interpreted to drape the entire channel, indicating periods of weaker gravity flows running down the channel, with no evidence of bedload transport. We propose a new depositional model for coarse-grained submarine channel systems, in which particular characteristics can provide significant insights into architectural heterogeneity and facies transitions in channelised systems.

Theme 7. Deep-marine clastic depositional systems

General Session

Oral presentation

Sedimentary architecture of turbidite channel–levee deposits: the Tachrift Project (Tachrift System, Taza–Guercif Basin, Late Tortonian, NE Morocco)

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For over 50 years, turbidite channel–levée complexes have been studied in various modern and ancient deep-water turbidite systems. Despite recent advancements in high-resolution 3D seismic imaging, their internal facies complexity remains elusive. Well-exposed outcrops are crucial in bridging this gap, as they offer insight into fine-scale facies heterogeneity. This contribution reports on the ongoing 'Tachrift Project', which aims to study unexplored spectacular outcrops of multiple superimposed channel–levée complexes in the Tachrift turbidite system of the Taza–Guercif Basin in NE Morocco (late Tortonian). The Tachrift Project has three main goals: (i) to study and understand the depositional architecture of deep-water channel–levée complexes, encompassing a range of channel-fill and levée elements; (ii) to provide a comprehensive overview of the evolution of channel–levée complexes, tracing their development from inception to their deactivation, and (iii) to establish a model for stratigraphic geometries and facies relationships in levéed-channel complexes. These aims are achieved through the following steps: i) 1:5000-scale geological mapping of 9 channel–levée turbidite complexes; ii) reconstruction of internal architecture and facies distribution by means of closely spaced detailed sedimentological logs, bed-by-bed physical correlation and interpreted 2D and 3D profiles; iii) statistical analysis to identify patterns and relationships; iv) creating 3D digital outcrop models of selected outcrops through photogrammetric data analysis obtained from UAVs. So far, the study has focused on complexes 4–7, aiming at completing the whole system by 2025. The preliminary results provided valuable information regarding the facies and geometry of channel-fills and correlative levees over a significant area of roughly 150 metres in thickness and 4 km in width. This transect runs largely oblique to the palaeoflow direction and gives a comprehensive understanding of the sedimentary heterogeneity and stratigraphic evolution of the turbidite channel belt. The findings from this research can be used to enhance existing models, also useful for the understanding of subsurface analogues, particularly about their variable architectures at different hierarchical scales.

Theme 7. Deep-marine clastic depositional systems

General Session

Oral presentation

Deep-water sedimentation in the Złatne Basin, Pieniny Klippen Belt, Carpathians, Poland

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The Pieniny Klippen Belt (PKB). is located in the suture zone between Central and Outer Carpathians in Austria, Slovakia, Poland and Ukraine. The PKB sedimentary successions were deposited within the Alpine Tethys. The Alpine Tethys contained two major basins – Złatne and Magura, separated by the Czorsztyn Ridge. The Jurassic–Lower Cretaceous successions of the Złatne Basin are represented mainly by deep-water carbonates and cherts. The Bajocian spotty shales marls and limestones of the Podzamcze Limestone Formation are followed by the Upper Bajocian–Lower Tithonian black cherts of the Sokolica Radiolarite Formation and green and red radiolarites of the Czajakowa Radiolarite Formation. The siliceous deposits were followed by the Upper Tithonian–Lower Cretaceous cherty limestones of the Pieniny Limestone Formation. These deposits are characterized by reduced thickness that does not exceed 30 m. They are followed by Albian–Neogene turbidite deposits sequences. The Albian–Cenomanian flysch of the Trawne Member is the first input of clastic turbidites within pelagic variegated marls of the Jaworki Formation. This formation is covered by the Upper Cretaceous Sromowce Formation represented by turbiditic siliciclastic flysch with exotic-rich conglomerates. The younger are uppermost Cretaceous–Paleocene, mainly coarse clastic rocks of Proč Formation covered by Eocene flysch of the Žilina Formation, Eocene–Oligocene turbidites of the Złatne Formation and Miocene flysch of the Kremna Formation. These formations contain intercalations of exotic conglomerates and olistostromes displaying a sedimentary mélange or “wildflysch” character. The olistoliths belong to Triassic–Cretaceous limestones, as well as Paleocene coral-algal reefal Kambühel limestones and Eocene nummulitic limestones. The Upper Cretaceous flysch of the Złatne Basin was deposited as a part the accretionary prism in front of the Carpathian Plate that reached and overrode the Czorsztyn Ridge during the latest Cretaceous–Paleocene times. The turbiditic and pelagic sedimentation continued in the piggy-back setting until Neogene times. Finally, the Złatne Basin and accretionary prism deposits were transformed into Złatne Unit (nappe).

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Theme 7. Deep-marine clastic depositional systems

General Session

Oral presentation

Sedimentary architecture and statistical data from the Late Tortonian deep-marine channel–levee Complex 5 (Tachrift System, Taza–Guercif Basin, NE Morocco)

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The Late Miocene infill of the Taza–Guercif Basin in NE Morocco represents a well-exposed record of deep-marine deposition adjacent to an ancient narrow sea-to-ocean connection (the Rifian Corridor). Impressive outcrops of the late Tortonian Tachrift system constitute a spectacularly exposed example of the basin's infill and offer the opportunity to study in detail the architecture of a series of deep-marine channel–levee complexes. Channel Complex 5 is exposed along a series of more than 1.5 km long, NW–SE oriented, laterally continuous outcrops, with a maximum stratigraphic thickness of 30 m. Excellent outcrop quality and lateral control of the exposures allowed the confident assessment of the sedimentary architecture of the Complex through the collection of 60 sedimentary logs. The collected log data were later transformed into a digital format to quantitatively assess trends such as net-to-gross, thickness variability, amalgamation ratio etc., across the channel belt. Stratigraphic organization consists of four stratigraphic units reflecting a shifting of the channel belt towards the east-southeast. From the bottom to the top, a thin to medium-bedded unit of small-scale sinuous channels represents an inception phase, which passes to a thick-bedded, amalgamated, mudclast-rich sandstone unit, typifying the main depositional phase of the complex, characterized by larger, aggradational, less sinuous channels. In the upper part, a thin to medium-bedded unit consisting of sigmoidal and amalgamated beds, represents a laterally accreting sinuous phase, which displays a coeval levee. Thinly-bedded turbidites at the top of the latter unit represent late-stage infills of the complex. A mud-dominated unit at the top reflects an abandonment phase and the shutdown of channel activity. Statistical results reveal the existence of quantifiable trends for some parameters (e.g., net-to-gross), which are different for each unit and could help towards detection of characteristics such as the lateral shifting of channel activity, the transition from channel to levee/overbank deposits or the estimation of lateral connectivity. A model of channel complex evolution based on the spatial distribution of quantifiable parameters, can be used as analogues to other sinuous channel fills.

Theme 7. Deep-marine clastic depositional systems

General Session

Poster presentation

Mid-Oligocene section of Maikop Formation from Kartli basin (Georgia) – environment and source rock characteristic

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The Maikop Formation is regarded as the key source rock in the Caspian and Black Sea regions. The Maikop is usually composed of a thick succession of clay-rich mudstones intercalated by sandstones, composing regional oil and gas plays. Most of the sedimentary rocks of this formation were deposited under reductive or oxygen depleted conditions. The clayey parts containing up to 15% total organic carbon. The stratigraphically constrained study coupled with a palynofacies analysis proceeded by transmitted microscopy and blue light excitation revealed wide range of particulate organic matter indicative for paleoenvironment. The quantitative and qualitative distribution of organic matter suggest high input of terrestrial particles and short distance form alimentation zones. It is proved by high diversity and state of preservation of fragile tissues (e.g. cuticle). Reduced ratio of phytoplankton is probably due to fresh water input indicated by scarce presence of chlorococcale algae represented by *Botryococcus*. However key taxa of dinoflagellate cysts served successfully for age assignment indicating Mid Oligocene interval. Under blue light excitation the studied samples yielded thermally matured sporomorphs, marine microplankton as well as common in all samples amorphous organic matter (AOM). Two generations of fluorescence are encountered within samples presumably caused by recycling or different organic matter compound. The autofluorescence colors recorded are comprised a range of light yellow to dark orange related to oil and gas windows respectively. Currently all samples are studied to record vitrinite reflectance index (R_o) and pyrolytic data to obtain wide range of maturity proxies.

Theme 7. Deep-marine clastic depositional systems

General Session

Poster presentation

The peculiarity of Precambrian and Paleozoic turbidites: influence of climate change and rise of land plants on delivery of sediment to the deep-sea

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During the Precambrian and Paleozoic, the evolution of the Earth was characterized by cyclic alternation of greenhouse and icehouse periods, which was accompanied by the appearance and spreading of land plants during the Paleozoic. These important external factors are known to have influenced the amount and type of sediments transported to the shelf. Potentially, these controls may have influenced the transfer of sediment by turbidity currents flowing through continental slopes to abyssal plains. However, a quantitative analysis of the effect of these controls on preserved sedimentary architectures has yet to be carried out. The aim of this study is to quantify the effect of global climate change and the evolution of land vegetation on the sedimentary architecture of turbidite systems. The main questions are: (I) how did these external factors influence the geometry and facies of turbidites? (II) Did the effect of icehouse and greenhouse conditions exerted on turbidite deposits differ before and after the appearance of land vegetation? This is achieved by using a database-driven approach to synthesize sedimentological data from 29 case studies, representing 15 deep-water clastic systems from the Neoproterozoic to the end of Permian. The analysed dataset includes 1,142 architectural elements (e.g. channels and lobes) and 12,370 facies entries. Pre-Devonian and younger Paleozoic deep-marine deposits, as well as sediments deposited under icehouse and greenhouse conditions, are equitably represented in the dataset. Preliminary observations revealed differences in the sedimentary architecture of turbidites deposited under icehouse and greenhouse periods and/or before and after the rise land plants. For example, turbidites and accompanying mud beds tends to be thinner, and turbidite lobes are characterized by lower net-to-gross values in systems that predates the spreading of land vegetation. Moreover, greenhouse terminal deposits are built up by thicker turbidite beds but have a lower total sand volume.These observations have implications for predicting subsurface architectures and should be considered during the evaluation of pre- and post-Paleozoic deep-marine successions deposited under different climates.

Theme 7. Deep-marine clastic depositional systems

General Session

Poster presentation

Control of tectonic-lithofacies palaeogeography on the development of marine shale – a case study on the Ulalik Formation of Ordos Basin (age and location?)

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The biological extinction in the middle and late Ordovician and rapid transgression led to the widespread distribution of a set of organic-rich shale in the world, which is internationally known as "hot shale", which is one of the most important exploration layers in the global Paleozoic oil and gas resources. Based on the latest 3D seismic data, a large number of field outcrops and core observations, this paper takes the Uralik Formation of Ordovician in the Ordos Basin as an example. The structural, lithofacies palaeogeographic characteristics and development model of marine shale are systematically studied. The following three new understandings have been obtained: (1) It is revealed that the western margin of the basin has a structural pattern of "three depressions and two uplifts" by the latest 3D seismic data. Due to back-arc tension and strike-slip, a large number of north–south synsedimentary faults developed in the western margin of the basin. (2) The synsedimentary faults not only control the structural framework and marine shale distribution of the Ulalik Formation in the western margin of the basin, but also control the lithofacies palaeogeographic distribution characteristics of the Ulalik period. (3) In the middle and late Ordovician, most areas of the Ordos Basin was uplifted, and the western margin rapidly subsided due to synsedimentary fault activity, forming an under-compensation and reduction environment, which is very conducive to the development of the Ulalik marine shale. Synsedimentary faults and rapid subsidence created an under-compensated reduction environment for the development of marine shale, and the hydrothermal activity provided by deep and large faults increased the marine shale paleoproductivity. This research is of positive significance for further exploring the formation environment and development model of marine shale in the western margin of the basin and guiding the practice of oil and gas exploration.

Theme 7. Deep-marine clastic depositional systems

General Session

Poster presentation

Investigation of deep water depositional elements of the Indus Submarine Fan through seismic facies analysis

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A seismic stratigraphy is a powerful tool for deciphering the sedimentary depositional environment and stratigraphic architecture of the subsurface geology in the absence of adequate well-bore controls. Recent developments in seismic facies analysis aid in decoding information on lithofacies and hydrodynamics in deep-water systems. This research employs the seismo-stratigraphic architecture of the Indus Submarine Fan system using seismic facies analysis on high-resolution multichannel industrial seismic data. Six unique seismic facies are identified by the seismic reflection characteristics, including amplitude, continuity, exterior form and interior configuration, frequency, peculiar waveforms, and location in sedimentary basins. These facies are (i) discontinuous low amplitude reflections (D-LARs) and (ii) continuous high amplitude reflections (C-HARs), indicating the wedge-shaped to convergent patterns that developed within or on either side of the channel as an inner or outer levee. (iii) Continuous low amplitude reflections (C-LARs), indicating the draping and sheet-like geometry with muddy turbidites in a condensed section of hemiplegics. iv) Discontinuous high-amplitude reflections (D-HARs), indicating wavy with sheet-like external forms and variable lithology mass flow units. v) Discontinuous chaotic high-amplitude reflections (D-C HARs) and vi) Continuous parallel high-amplitude reflections (C-P HARs) as channel deposits of high–low-energy turbidity currents. The spatio-temporal distribution of these facies implies the development of (i) erosional channels as confined depositional systems along the shelf margin and upper continental slope; (ii) erosional–depositional channels as a semi-unconfined system along the slope; and (iii) depositional channels and associated basin deposits as unconfined systems. These channel deposits' stratigraphic imprints are the result of the continental slope's base-level profile changing due to regional factors such as local tectonics, eustacy, and climate effects. The preliminary results of this study demonstrate the research potential of the data and provide insight into the sedimentary dynamics and depositional features of the Indus submarine fan, despite it being the second largest but least studied submarine fan.

Theme 7. Deep-marine clastic depositional systems

General Session

Poster presentation

Sedimentary architecture of a channel–levee complex from the Taza–Guercif Basin (Late Tortonian, NE Morocco)

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Spectacularly exposed outcrops record the Late Miocene infill of the Taza–Guercif Basin (NE Morocco), which was part of the ancient seaway connecting the paleo-Mediterranean Sea and the Atlantic Ocean. This work presents the sedimentary architecture of channel–levee Complex 7, one of the channel–levee complexes constituting the Tachrift system. The excellent lateral continuity and quality of the outcrop allowed acquisition of 60 closely spaced (ca. 25 m), detailed (scale 1:20) sedimentary logs. This approach allowed a good control over interpretation of the depositional architecture of the complex. The resulting correlation panel shows the spatio–temporal evolution of the complex, which can be subdivided in two main stages. The first stage shows aggradation and a general lateral eastward migration of the channel belt. It begins with horizontally arranged sandstone beds (15 to 50 cm thick) with small mudstone caps. It continues with amalgamated beds (up to 1 m thick) that record the migration of the system towards the E in lateral accretion packages. Finally, in upper stratigraphic levels a late phase is characterised by small-scale channels that represent the shut-down of the system. In this first stage, a progressive reduction of sedimentary input is observed. The second stage represents an increase in erosive processes. At the base, we observe a mass-transport deposit (2 m thick) eroding the underlying beds, creating a confined channel system that tends to overspill as the accommodation space decrease. In the second stage, a rapid increase in sedimentary input is observed. The two stages show different depositional styles, the first being less erosive, unconfined and more prone to migration. The second is more erosive, confined and without effective migration. An example of a sedimentary architecture like the one here described can help calibrate a future depositional model that can be used as an analogue for other sinuous channel systems.

Theme 7. Deep-marine clastic depositional systems

General Session

Poster presentation

Significance of siliciclastic deposits in marl-dominated deep-water proximal setting (Turonian–Paleocene Ropianka Formation, Polish Outer Carpathians)

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Deep-water sedimentary basins are predominantly filled by siliciclastic or carbonate deposits, whose origin can be controlled by different sedimentary mechanisms. The Turonian–Paleocene deposits of the Ropianka Formation (Skole Nappe, Polish Outer Carpathians) include both siliciclastic and carbonate deposits representing a relatively proximal zone in the western part of the basin. Based on the facies analysis with high-resolution bed-by-bed stratigraphic succession logging, interpretation of the depositional processes, and statistical characterisation of distinguished facies associations, depositional setting was interpreted and subdivided into well-established subenvironments of the turbidite system. The Campanian–Maastrichtian evolution of the Skole Basin shows progradational–retrogradational cycles and the corresponding shifts from carbonate to siliciclastic dominated sedimentation, mostly as a result of relative sea-level changes and tectonic activity. In a smaller scale, two studied intervals with high contribution of carbonate deposits were influenced by the siliciclastic sedimentation. Field studies revealed carbonate facies associations characterised by the occurrence of deposits indicating sediment bypass and abundant small-scale erosional features. Despite domination of marls this bypass zone tends to show a higher contribution of lag deposits or dune scale bedforms with intraformational clasts. Such types of deposit may be a useful tool for tracking periods of turbidite system progradation, and perhaps small-scale sea level changes or tectonic pulses in a deep-water sedimentary successions dominated by fine-grained sedimentation.

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Theme 7. Deep-marine clastic depositional systems

General Session

Poster presentation

Architectural organization of the Tachrift channel–levee Complex 5 (Late Tortonian, Taza–Guercif Basin, Morocco) based on detailed sedimentary log correlation

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Impressive outcrops of Late Miocene aged deep-marine sediments are exposed near Taza (NE Morocco), deposited adjacent to the Rifian Corridor during the late Tortonian. Excellent outcrop exposure allowed the detailed logging and three-dimensional observation of turbidite sediments interpreted as sinuous channel fills, forming a succession of channel–levee complexes. Channel Complex 5 is exposed along ~1.5 km of NW–SE oriented, laterally continuous outcrops. High outcrop quality and lateral control allows confident assessment of the sedimentary architecture, which was characterized with the acquisition of 60 sedimentary logs. These allowed the construction of a detailed stratigraphic panel, revealing the architectural organization of the Complex, through the succession of four genetic units, revealing modifications of the parent channel course. The lower unit (Unit 1) is composed of thin- to medium-bedded turbidites, forming laterally extensive, locally amalgamated and laterally accreted bedsets, fringing laterally into mud-prone heterolithics. These deposits represent frontal splays and subsequent small-scale meandering channels, with subtle muddy levees. The overlying Unit 2 is erosionally-based, thicker-bedded and bounded by well-developed sand-rich levees. It comprises amalgamated sandstones, rich in mud-clasts, which pass downstream to a sigmoidal sandstone body made of more thinly-bedded and finer grained amalgamated sandstones. Deposits of this unit represent the asymmetrical fill of a sinuous channel, which aggraded contemporaneously to its levees. In the upper levels, Unit 3 is typified by coarser, thicker, and locally amalgamated cross-stratified sandstones, featuring larger-scale sigmoidal bedding, which pass down-current to non-amalgamated sandstones with bar-like geometries. This unit is characterized by an irregular top surface interpreted to reflect establishment of a meandering channel, partially infilled by accretion processes at its inner banks. Finally, the heterolithic Unit 4 onlaps the top surface of Unit 3 and is characterized by a fining-upward stratigraphy, which represents a phase of channel shutdown. The documented channel–levee architecture can be used as a high-resolution analogue for sinuous channel systems.

Theme 7. Deep-marine clastic depositional systems

General Session

Poster presentation

Depositional processes in deep-water Caledonian pre-flysch basin recorded in Silurian carbonate concretions and calcified tuffites of the Holy Cross Mountains (Poland)

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Sedimentary conditions and depositional processes in the Caledonian pre-flysch basin of the Holy Cross Mountains (SE Poland) have been studied through the analysis of Silurian carbonate concretions and calcified tuffites. The sedimentological research has been conducted on samples from three natural outcrops and two drilling cores. The early diagenetic genesis facilitated the preservation of original sedimentary structures in the studied concretions and tuffites. A relatively deep-water foreland basin was formed in the Wenlock to Early Ludlow time span along the present-day SW margin of Baltica as a result of the collision with a volcanic arc located west- or south-westward. The depositional regime in this basin was dominated by accumulation of fine-grained clastic sediment influenced by the intermittent benthic anoxia. The investigated interval (Wenlock–Lower Ludlow) consists of graptolitic claystones and mudstones, which were largely deposited from the suspension fall-out, periodically the sedimentary conditions were affected by weak bottom currents. The entire succession is quite monotonous and homogeneous because compaction has obliterated its original structures. Therefore, the early diagenetic carbonate concretions provide an opportunity for insight into the primary sedimentary conditions. The mudstones contain laminasets of pelleted, burrow-mottled and homogenized laminae with framboidal pyrite, clay minerals, fibre-like organic matter and mica flakes. They are intercalated by numerous calcified volcanic ash beds, up to 3–4 cm thick. Most of them show normal grading, however, in a few cases reverse grading has been also noted. Some beds show erosional basal contact overlain by quartz/feldspar silt that grades upward into laminated clay or single current ripples. The carbonate nodules reveal thin undulating laminaets with erosional surfaces and inserts of tiny shell/crinoid debris that seem to be produced by high-energy events. The $\delta^{13}C$ signature of carbonate concretions has been also determined and obtained values range from -12.1 to 0.9‰. Together with other sedimentological features they indicate that isotopically heavier concretions were formed under the sulphate-reducing conditions, while the lighter ones may be related to the periodic anaerobic oxidation of methane.

Theme 7. Deep-marine clastic depositional systems

General Session

Poster presentation

The influence of tectonic confinement on lateral and vertical turbidite facies distribution (Firenzuola Turbidite System, Marnoso–Arenacea Formation, Italy)

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This work focuses on the serravallian foredeep turbidites of the Marnoso–Arenacea Formation (MAF), known in the literature as the Firenzuola system or Unit V. This Unit records progressive closure of the MAF inner basin and consequent depocenter shift toward the outer basin due to the coeval growth of two regional tectonic structures parallel and perpendicular to paleocurrents, which are the Mt. Castellaccio thrust and the Verghereto high. Unit V depositions is also controlled by the Casaglia mass transport complex (MTC), a 500 m thick transversal unit. The main goal is to provide a high-resolution stratigraphic framework of Unit V, thanks to bed-by-bed correlations and a detailed facies analysis. Grain size was also analyzed using a laser diffraction granulometer for characterizing facies and sedimentary structures. As shown in previous works, Unit V can be subdivided into two sub-units, Unit Va and Unit Vb, separated by the Bedetta MTC, found for the first time in the study area. This MTC testifies a further basin narrowing phase and an increase in basin confinement that favour flow deceleration and possible hydraulic jumps. This is testified, in Unit Vb, by the drastic increase in the sandstone–mudstone ratio, mud-draped scours and massive to crudely laminated coarse-grained sandstones characterized by widespread occurrence of mudstone clasts, flame structures and traction bypass facies. In fact, while Unit Va is dominated by contained reflected beds that tend to be controlled by the morphological barrier created by Casaglia MTC, Unit Vb is dominated by facies recording high deceleration rates of basal high-density supercritical flows and the bypass of low-density turbulent flows. These processes influence the lateral and vertical facies variations of depositional lobes, as well as their geometries. This work has allowed a paleogeographic reconstruction of this portion of the basin, which can be particularly suitable for stratigraphic modeling and analogs for laboratory experiments. A subdivision of Unit Vb in depositional lobes is also provided, in order to better understand lobe and interlobe geometries, architectural hierarchy and depositional mechanisms.

Theme 7. Deep-marine clastic depositional systems

General Session

Poster presentation

Architecture, evolution, and controls of channel–levee: Complex 4 from the Tachrift System (Taza–Guercif Basin, NE Morocco)

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The sedimentary architecture of channelised turbidites can be highly complex as it reflects the response of submarine channels to several interplaying factors, both allocyclic and autocyclic. Although largely studied through seismic imaging, turbidite channel fills are not satisfactorily understood for sedimentary facies and small-scale architectures at a sub-seismic scale. This contribution reports on the sedimentary architecture and the controls on the evolution of a ca. 20 m-thick channel–levee Complex 4 of the Tachrift system, which accumulated during the Late Tortonian onto the southern slope of the Neogene Taza–Guercif Basin (Rifean Corridor, NE Morocco). The elemental building blocks of studied channel–levee complex are single-storey channel fills and associated levees. Single-storeys are made of a few to several event beds that in channel fills can stack vertically in a cut-and-fill fashion, or laterally, forming lateral accretion packages (LAPs) with an overall sigmoidal shape. The elemental blocks are organized to form the architecture of Complex 4, which evolves from base to top: (i) a ca. 7 m-thick mud-prone interval containing relatively small and vertically stacked channel fills with poorly developed muddy levees, (ii) a ca. 4 m-thick and >1 km-wide sandstone-rich middle interval made of LAPs which is progressively less amalgamated upward and overlain by ca. 5 m of cm-thick sandstone intercalated with hemiplegic marlstones, and (iii) ca. 9 m-thick upper interval constituted by vertically stacked channel fills, made of variously directed LAPs, associated with well-developed levees. This architecture suggests that, following a phase of inception (i), the channel underwent extensive meandering with very minor vertical aggradation, prior to be blanketed by 'retrogressive' muddier deposits (ii) during a phase of reduced sediment input. In turn, the uppermost interval (iii) records a late phase of channel re-establishment and aggradation. The identified changes of architectural style are interpreted to reflect the response of variations in sediment supply and flow properties at temporal scales shorter than c. 30 kyr (estimated duration of Complex 4), and can be modulated by long-term adjustment of submarine channels to profile of equilibrium.

Theme 7. Deep-marine clastic depositional systems

General Session

Poster presentation

Sedimentary characteristics and basin evolution of a compartmentalized foreland basin – Internal Ionian Zone, Western Greece

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Depositional environments in foreland basins settings is mainly controlled by submarine fan deposits. The goal of the study was to study the Late Eocene–Oligocene submarine fan exposures of the Internal Ionian zone in Greece and to identify potential reservoir units. The study was based on the detailed sedimentological analysis of eleven sections through the Late Eocene–Oligocene flysch formation of the Internal Ionian Zone (IIZ) in Western Greece. The sections are spread to Epirus and Aitolokarnania regions. Paleocurrent and biostratigraphic analysis completed the available dataset. The onset from carbonate-to-clastic sedimentation occurred during upper Eocene, forming a 100–200 m thick unit (Unit I), which consists of a lower marly transitional zone with thin intercalations of calciturbidites and limestones that upwards grades into mudstone with thin (< 0.3 m) sandstone/siltstone beds. Unit I is overlain by a succession of thicker (< 1 m) and coarser-grained sandstone beds regarded as UNIT II. Paleoflow measurements from flute and groove marks indicate an east to west flow direction of the turbidity currents, suggesting deposition on open unconfined basins. Intervals of thick amalgamated sandstones and conglomerates intercalated with thick-bedded heterolithics characterize Unit III (Lower Oligocene). The flow direction of the turbidity currents is axial and both, north to south and south to north. Based on thickness variations and grain-size, the source of the turbidity currents is near the boundaries of the pre-existing Eocene basins, which might have evolved into large strike-slip zones. The mud-dominated flysch deposits in Unit IV suggest a placid tectonic time interval during middle Oligocene. Intervals of thick amalgamated sandstones and conglomerates to thick-bedded heterolithics in Unit V (Upper Oligocene) probably indicate the age that thrusts started to penetrate within the IIZ The presence of abundant local to basin-scale mass-transport deposits is also consistent with strong tectonic activity at this time interval. Based on facies associations distributions 5 distinct units have been identified in the IIZ flysch deposits. In terms of reservoir characterization units III and V and in a lesser degree Unit II could be regarded as potential reservoirs.

Theme 7. Deep-marine clastic depositional systems

General Session

Poster presentation

Structural characteristics and deep-water hydrocarbon accumulation model of the Scotia Basin, Eastern Canada

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Commercial hydrocarbon reservoirs have been discovered in shallow-water areas of the Scotia Basin, Eastern Canada. However, knowledge about the structure and hydrocarbon accumulation characteristics of the basin is still insufficient, which constrains the petroleum exploration in deep-water areas. Based on comprehensive data of drilling, seismic survey, and magnetic anomalies, this study determines the structure characteristics of the Scotia Basin and its hydrocarbon accumulation conditions in deep waters, and evaluates the deep-water hydrocarbon exploration potential. The transform faults in the northern basin and basement properties of the basin control the sedimentary framework showing thick strata in east and thin strata in west of the basin. The bowl-shaped depression strata formed by thermal subsidence during the transitional phase and the confined environment (micro basins) caused by salt tectonics provide favorable conditions for the development of source rocks during the depression stage of the basin. The progradation of large shelf-margin deltas during the drift phase and steep continental slope provide favorable conditions for the deposition of slope-floor fans. Moreover, the source–reservoir assemblage comprising source rocks in the depression stage and the turbidite sandstones in the drift phase may form large deep-water turbidite sandstone reservoirs. This study may provide a valuable reference for the deep-water hydrocarbon exploration in the Scotia Basin.

Theme 7. Deep-marine clastic depositional systems

General Session

Poster presentation

Turbidite channel-levee transitions: the Complex 6 of the Tachrift system (Taza–Guercif Basin, NE Morocco)

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Identification of turbidite channel–levee deposits in ancient strata is of particular significance in subsurface modelling of deep-water systems, where data are restricted to narrow borehole sections or seismic images. As with areas of discontinuous outcrop, interpretation of the temporal relationship of channel–levee systems is largely based upon inference. Moreover, documented outcrops where accordant channel fills and overbank sediments can be observed with continuity are few/small. We present the outcrop of Complex 6, one of multiple turbidite channel–levee complexes making the Tachrift system (late Tortonian–early Messinian), exposed in NE Morocco as part of the clastic fill of Taza–Guercif Basin. Goal is to document geometry, facies assemblages, and their vertical–lateral stacking within Complex 6, to be integrated with the ongoing surveys of the basin fill. The method integrates geological mapping, facies analysis on 46 logs, and physical stratigraphic correlations. Complex 6 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. Vertical and lateral facies associations and changes in units B and C suggest that channel-fill deposits and genetically linked levees have different crossflow facies tracts, recording changes in flow parameters and morpho-dynamics of the parent channel. The two end member types represent the product of deposition in sinuous meandering channels and relatively straight non-meandering channels: i) asymmetrical channel-fills, dominated by lateral accretion packages that make transition to levees at the accreting inner bank, showing complex lateral relationship with the outer bank levee; ii) symmetrical channel-fills, in which channelised amalgamated sandstones laterally pass into sandy levee crests, then to mud-prone outer levee heterolithics. Facies associations and 3D stratigraphic architecture of Complex 6 reveal 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.

Theme 8. General topics in clastic sedimentology

Special Session 8.1. Subaqueous sediment gravity flow processes and products

Oral presentation

Evaluation of turbulent diffusion of suspended particulates

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Sediment suspension in turbulent flows can be considered analogous to a diffusion–dispersion process, where turbulent diffusion of sediment is related to turbulent momentum (eddy) diffusivity by the ratio β. Currently, there is no agreement in the literature concerning an appropriate value of β, nor the physical reasons for why it may vary. Here laboratory data are presented for dilute flow over upper stage plane beds and both uniform and nonuniform sediment, covering silt and sand particle sizes. For the first time, experimental analysis involving decomposing β for separate particle size fractions shows that β varies by several orders in magnitude and β increases with increasing ratio of settling velocity and shear velocity, ws/u*. A new relation for β is proposed based on a combination of two previous relations, covering 0.01<ws/u* <1. This relation represents a lower limit for capacity conditions over upper-stage plane beds, with higher values expected for noncapacity (reduced) concentrations and for flow over bedforms. Comparison is made between the bulk concentration predicted using the proposed β=f (ws/u*) relation versus β=1, suggesting that the latter commonly held simplification overestimates sediment concentrations for suspended-load-dominated flows.

Theme 8. General topics in clastic sedimentology

Special Session 8.1. Subaqueous sediment gravity flow processes and products

Oral presentation

Predicting pre-lithification mud bed density and yield stress from chevron marks and striated groove marks

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Our understanding of the formative conditions of sole structures is limited, with the formation of chevron and striated groove marks remaining particularly enigmatic. We conducted laboratory experiments of these sedimentary structures by dragging an idealised armoured mud clast through substrates of different density, composed of kaolinite–seawater mixtures, to represent the seabed, and covered by seawater. Chevron marks formed over a narrow range of substrate densities, likely explaining their relative rarity in nature. Furthermore, their form depends on substrate strength, with chevron angle relative to the movement direction of the clast being less in weaker substrates. Moreover, cut chevron marks, characterised by a thin central stripe that separates the chevrons, bear no relationship to the size of the incising clast, but rather reflect a weak substrate that is sufficiently mobile to close behind the clast. In contrast, interrupted chevron marks, with a more pronounced central groove, reflect greater substrate strength, and striated groove marks without chevrons form in the substrates with the highest strength. Our experiments also suggest that armoured mud clasts are the likely tools to produce fine striae in striated grooves, and hence that these clasts are more prevalent in some deep-marine settings than previously thought. The observed changes from cut chevrons, via interrupted chevrons with striated grooves, to striated grooves without chevrons, in combination with changes in chevron angle, enables these sole structures to be used as indicators of palaeosubstrate rheology, provided that specific conditions are present to preserve chevron marks in the characteristically weak substrates in which they form. These conditions include a prolonged period of bed consolidation, flow bypass, and lack of bioturbation caused by low oxygen levels. Given changes in seafloor communities and bioturbation over geological time and their impact on substrate rheology, our work suggests that the frequency of these sole structures likely altered with the evolution of burrowing organisms.

Theme 8. General topics in clastic sedimentology

Special Session 8.1. Subaqueous sediment gravity flow processes and products

Oral presentation

Quantifiying water entrainment processes in turbidity currents by direct measurements in the Monterey Canyon (California)

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Turbidity currents rival rivers in their global capacity to transport sediment. Yet, unlike rivers, there are currently no models that predict the down-channel evolution of turbidity currents. The most import limitation is the uncertainty in quantifying the entrainment of sediment and water into these flows. Here we present unique field data that allows us, for the first time, to quantify the water entrainment of full-scale turbidity currents as they evolve down the Monterey Canyon. We use these data to test existing water entrainment models. Additionally, we use temperature measurements to show that colder ambient water is mainly entrained through the nose of the flow. Finally, we present a new conceptual model of a turbidity current that is mainly entraining ambient water through the nose of the flow while de-training along most of the top interface, this in contrast to the previous models that emphasized water entrainment along the top interface.

Theme 8. General topics in clastic sedimentology

Special Session 8.1. Subaqueous sediment gravity flow processes and products

Keynote lecture

A new process model for hybrid event beds: the importance of debritic heads

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Hybrid event beds are widely recognised, and a number of different models exist that explain their genesis. These models work well for initial high concentration failures that transform downdip. However, flows that transform from initially dilute to high concentration with distance downstream are much less well explained by existing models. In particular, existing hybrid event bed models do not explain the process mechanics responsible for forming the debritic (H3) division through the addition of mud clasts eroded en route. Furthermore, these models also do not explain how groove marks can be found directly underneath hybrid event beds. The presence of such grooves (with their constant depth and width) has in turn been linked to debris flows that have sufficient cohesive strength to be able to maintain a tool (clast) in a fixed position whilst cutting through a mud-rich substrate. Here we integrate field data from the Aberystwyth Grits, Wales, with literature data to propose a new process model of hybrid event beds. In this model, erosion is focused at the front of the turbidity current, reflecting experiments and numerical simulations. This erosion of mud increases the density of the head, or a 'flow cell' right at the front of the head (cf. Congo turbidity currents). Clasts are initially eroded and travel as bedload. This bedload travels slower than suspended sediment, with clast velocity decreasing with increasing grain size. Therefore, mud clasts move backwards relative to the head, with clasts undergoing size segregation. The presence of grooves and their genetic link to hybrid beds, as shown in the Aberystwyth Grits, shows that the head of the flow can transform fully into a debris flow. As the flow decelerates, cohesive forces become more important, vertical segregation commences behind the head, and the H1 sand division starts to aggrade. Most of the bedload will bypass the top of this solid aggrading surface, but isolated clasts can be incorporated. As the flow further increases in cohesion, buoyant forces become important, and the bedload fraction starts to be incorporated into high-strength transitional flows where minor segregation can still occur, then into a true debris flow (H3). Low concentration components of the flow follow (H4/H5). This model thus combines vertical and longitudinal segregation.

Theme 8. General topics in clastic sedimentology

Special Session 8.1. Subaqueous sediment gravity flow processes and products

Oral presentation

The role of hyperpycnal flows in the preservation of fossil medusae in the Eocene flysch from the Slovenian coast

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Medusae often form blooms in many contemporary marine environments and subsequently accumulate in great numbers on the sea floor. Despite their presumed abundance in ancient oceans, their fossil record is comparatively rare, especially in deep marine deposits. Herein, evidence of such an event in the Eocene flysch of the Slovenian coast is presented. The flysch is generally of very distal character and consists of alternating marly mudstones and thin beds of fine-grained siliciclastic turbidites. Exceptionally, near the town of Škofije, an interval of thick-bedded, medium-grained sandstone is quarried, where numerous unusual circular structures occur on the lower bedding plane of a particular thicker laminated sandstone bed. They are circular to ellipsoidal, 6.5–24.5 cm in diameter, and generally isolated. Some of them partly overlap. The best-preserved specimens have two rings and thin radially disturbed "stripes" between them. Additional small transverse ribs occur in the central part, although poorly expressed. These structures are interpreted as fossil medusae. The morphology is consistent with that of cnidarian medusae and appears to be analogues of extant scyphozoan *Discomedusae*. Thin sections crossing the selected specimen show that only the lowermost laminae were deformed by the structure, while the higher laminae are undisturbed in the remaining part of the bed. This bed is probably not turbiditic, but was formed by a hyperpycnal flow that gradually accumulated the sand on the seafloor. The medusae were laying on the marly mud on the seafloor (probably dead) after a great medusae bloom enhanced by a humid episode. The same weather conditions caused hyperpycnal flows that covered the medusae. After the initiation of the flow, the first sand layers gradually seeped into the decaying bodies and later formed the 95 cm thick bed. In the laboratory, an experiment with recent medusae was conducted. It shows that such fossilisation is possible. In the future, detailed biostratigraphic and mineralogical studies that aim to connect the studied succession to one of the Eocene humid/warming episodes are planned.

Theme 8. General topics in clastic sedimentology

Special Session 8.1. Subaqueous sediment gravity flow processes and products

Poster presentation

Coarse-grained channel–lobe transition zone and channel–levee complex in Late Eocene deposits from Colombian Caribbean

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Sediment-laden turbidity currents and other sediment-rich gravity currents are well-studied depositional processes. However, the identification of the transitional zone between the submarine channels and lobes may be challenging due to the high geomorphological dynamics involved. The discovery of rare-exhumed-channel–mouth systems can provide valuable insights for this identification. This study analyses two Late Eocene sections from the San Jacinto Formation in the Colombian Caribbean, the San Jacinto and Arroyo Alférez creeks, which are dominated by coarse-grained deposits. These sections consist of meter-thick sigmoidal and lens-shape gravels; foreset and backset cross-stratified pebbly sandstones; and low-angle, upflow-dipping, undulated-stratified (antidunes) granule and coarse-grained sandstones filling gently scours (cut-and-fill structures). Additionally, layers of centimetric-thick mudstones with horizontal bedding containing abundant benthic foraminifera have been identified. These features provide insights about a coarse-grained mouth-bar migration and antidunes linked to supercritical flows. Therefore, the channel-lobe transition zone is characterized where the channel (or canyon) loses confinement from the mouth towards an antidune setting. The aforementioned deposits are located below the highly bioturbated and thinly layered sandstones (including *Ophiomorpha* and *Thalassinoides*), and mudstones (including *Chondrites*, *Phycosiphon*, and *Teichichnus*) with benthic foraminifera, load casts and flame structures, which are associated with low-density turbidites in a levee system. Successions of meter-scale sharp- and erosional based, fining-upward sequences with basal massive matrix-supported pebble conglomerates (including hard, extrabasinal clasts, rip-up mud clasts, and coastal bioclasts), which evolved upwards from liquefied massive to planar-laminated coarse-grained sandstones with phytodetrital carbonaceous laminae, overlay the deposits. The structures are defining the channel fills with cohesionless debris flow (bypass) and concentrated flow deposits (high-density turbidites) coming from fluvial or coastal systems (i.e., delta). This study suggests the evolution from the channel–lobe transition zone to a channel–levee complex.

Theme 8. General topics in clastic sedimentology

Special Session 8.1. Subaqueous sediment gravity flow processes and products

Poster presentation

Holocene sedimentary processes in submarine canyons offshore Pointe-des-Monts (Lower St. Lawrence Estuary, Canada)

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A system of small, but active submarine canyons without riverine sedimentary inputs was identified offshore Pointe-des-Monts (PDM) in the Lower St. Lawrence Estuary (eastern Canada). Previous work has demonstrated that storms initiate sediment resuspension and turbidity currents in these submarine canyons. However, the Holocene sedimentary processes operating in the PDM canyons and their relationship to regional climate and oceanography remain poorly understood. In this context, we investigated sedimentary facies and depositional history of the PDM submarine canyons during the Holocene in order to reconstruct the history of storm-induced turbidity currents. To reach these objectives, we conducted grain size, mineralogical, chemical elemental analyses (pXRF) and physical properties analyses (e.g., density, magnetic susceptibility, diffuse spectral reflectance, etc.) of several sediment cores collected during five different sampling campaigns onboard the R/V Coriolis II and CCGS Amundsen. Our results indicate the presence of 1) normally-graded sandy intervals, sometimes massive, with erosive basal contacts interpreted as turbidites and 2) intervals with inverse then normally graded sand with gradual contacts and intervals with inverse grading suddenly changing to a finer grain size, which likely results from the reworking of turbidites and hemipelagites by bottom currents. Radiocarbon dating reveals that the PDM submarine canyons have been active for at least 6000 years. Grain size, mineralogical and elemental analyses on samples from box cores and sediment traps deployed in the main canyon fan in order to study historical and modern sedimentary dynamics are ongoing and will also be presented.

Theme 8. General topics in clastic sedimentology

Special Session 8.1. Subaqueous sediment gravity flow processes and products

Poster presentation

Stratigraphic cycles in turbidite sand sheet systems – implications for progradation/retrogradation cycles

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Attempts have been made in the past to link stratigraphic cycles in turbidite sequences to progradation (i.e. thickening and coarsening upward) and retrogradation (thinning and fining upward). However, if the sedimentary system is laterally unconfined or shows much compensational stacking, the relationship between stratigraphic cycles and such vertical sequences may be more complex or stochastic. Meanwhile, progradation and retrogradation imply a basinward or landward shift in deposition respectively, but few 2D outcrop sections along depositional dip have been studied sufficiently to establish the longitudinal variations in stratigraphic cycles. In this study, two Cretaceous turbidite sand sheet systems, referred to as Pehoe Member B and Paine Member A (abbreviated here to Pehoe B and Paine A) are compared, to investigate the longitudinal stratigraphic variation and possible implications. With a logging scale of 1:10, statistical methods such as runs tests, moving average, and correspondence tests are used to detect stratigraphic cycles. Combined with facies and thickness analysis, Pehoe B and Paine A sand sheet systems are both interpreted to be laterally confined with dominantly vertical stacking overall. Along depositional dip, stratigraphic cycles of thickening and coarsening upward then thinning and fining upward, where present, are asymmetrical in proximal areas but appear to be more symmetrical in distal areas. The longitudinal variation of stratigraphic cycles is generally consistent with that of maximum thickness of amalgamated beds and total counts or counts/meter of all bypass features. Turbidite vertical sequences of both Pehoe B and Paine A reflect a general progradation then retrogradation process, with superimposed small scale fluctuations, which may infer allogenic variations in sediment supply (3rd to 4th order sequences).

Theme 8. General topics in clastic sedimentology

Special Session 8.2. Analogues and experiments for understanding early diagenesis of clastic sediments

Oral presentation

The role of biofilms in clay coating of deep water deposits

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Clay-coating processes have long been discussed in literature and several mechanisms have been suggested as key in the generation, including co-deposition, infiltration, bioturbation-induced sediment mixing and a biofilm origin. Recent studies suggest extracellular polymeric substances (EPS), a fundamental constituent of biofilms, play an important role in the formation of clay-coating of grains by forming an adhesive coat around sand grains. This adhesive acts as a binding site for clay minerals. Here we investigate clay coat formation in modern deep-water settings using sediment samples from Bute Inlet (Canada) and the Congo Canyon (W Africa). Biological geochemical proxies (chlorophyll a and total carbohydrate content) were used to investigate the role of biofilms in the formation of clay-coated grains. Although previous studies in marginal coastal settings have shown a significant and positive correlation of clay-coat coverage with total carbohydrate and chlorophyll a content across delta and estuarine sediments, this relationship is less established in deep water sediments. This suggests that most clay coats are likely to be formed in marginal marine settings, such as deltas, estuaries and coastal seas and transported to the deep-sea with an intact/semi-intact coat coverage. Preservation of coats during transport is likely to depend upon the coat thickness as well as the clay type. The implications of these findings for understanding transport histories and paleo environmental processes resulting the deep water deposits will be discussed.

Theme 8. General topics in clastic sedimentology

Special Session 8.2. Analogues and experiments for understanding early diagenesis of clastic sediments

Oral presentation

Interdependence between bacterial EPS and early grain coat development

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Bacteria are the most abundant forms of life we know on our planet, able to survive in a variety of habitats, that play an important role in mineral formation and transformation processes. Here, we present laboratory experiments in which unconsolidated quartz grains were seeded with *Geobacter sulfurreducens* cells and exposed to a mineral medium solution for 96 hours at temperatures of between 60 and 120°C. Experimental data show the interdependence between extracellular polymeric substances (EPS) and the early formation of grain-coating material. The occurrence of EPS promotes the development of web and bridging structures binding the quartz grains and creating EPS-coated surfaces. With increasing temperature, an amorphous mineral phase grows preferentially on these surfaces suggesting that EPS can act as a template for mineral nucleation. At temperatures >100°C, the order of crystallinity of the amorphous authigenic phase increases, transitioning to poorly-ordered rosette-like textures.

Theme 8. General topics in clastic sedimentology

Special Session 8.2. Analogues and experiments for understanding early diagenesis of clastic sediments

Oral presentation

Understanding the origin and distribution of reservoir quality enhancing clay grain coats in the modern, macro-tidal estuary using optimised machine learning

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The Ravenglass Estuary in Cumbria, NW England, UK, has been used as a test-bed to develop new understanding of sedimentary sub-depositional environments and how they relate to sediment accumulation, erosion and re-deposition, sediment mineralogy, sediment grain size attributes (sediment texture), clay grain coats and early diagenetic processes. Sediment texture remains a universal attribute of all sediments when key diagnostic features, used to interpret the sub-depositional environment, are obscured or not present. Here we present an automated, supervised machine learning-based classification workflow which implements Extreme Gradient Boosting and Bayesian Optimization of hyperparameters to differentiate estuarine sub-depositional environments. We use nineteen textural attributes, measured using laser particle size analysis of surface sediment samples to make unbiased classification of sub-depositional environment. The predictive model created using the automated workflow has been evaluated using a suite of evaluation metrics, confusion matrices, and spatial analysis to understand the geological implications. The surface calibrated model has then been applied to textural data, obtained at 5 cm intervals, from Holocene geotechnical cores (up to 12 m) drilled through the Ravenglass Estuary succession, in order to classify paleo sub-depositional environment. The distribution of clay grain coats has been measured at the surface, and a statistically significant correlation has been found between surface sub-environment and clay grain coat coverage. The observed trends in clay grain coat coverage and sub-environment at the surface are similar to the subsurface in the Ravenglass estuary. The implication of this is that we can use the relationship between clay coat coverage and sub-depositional environment at the surface to infer clay coat coverage in the sub-surface. Stratigraphic correlation panels can therefore be used to predict the occurrence of reservoir quality enhancing grain coating clays.

Theme 8. General topics in clastic sedimentology

Special Session 8.2. Analogues and experiments for understanding early diagenesis of clastic sediments

Oral presentation

From loose sand to sandstone: experimental approach of early calcite cementation in sandstones

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In this study we produced synthetically cemented sandstones to assess the impact of detrital texture and composition on the precipitation and distribution of early calcite cement, and cement-related degradation in porosity and permeability. X-ray micro-CT was implemented to quantify porosity and permeability after cementation and to visualise precipitation patterns, while high resolution 2D optical and scanning electron microscopy were used to track micron scale features. To simulate early-calcite cementation, loose sediment of variable composition and grain size was exposed to a calcite supersaturated solution for 30 to 60 days at 20°C. The experimental results show the precipitation of grain-rimming, pore-bridging and pore-filling granular calcite cement with up to 100 µm crystal size. Despite a positive correlation between the amount of carbonate grains and calcite crystals, calcite cement does not preferentially nucleate on bioclast surfaces, irrespectively of their favourable mineralogy. Grain size variations within the grain packs have influence on the precipitation pattern of calcite with coarse-grained layers (500–710 µm) showing minor calcite cementation (6.3%), while medium- (250–500 µm) to fine-grained layers (125–250 µm) comprise average calcite cement contents of 16.3% and 28.2%, respectively. Initial physical compaction experiments utilizing distilled water as pore fluid at an effective stress of 27.58 MPa (4000 psi) and sample temperature of 50°C before and after cementation of the grain packs highlight the increase of mechanical strength and the reduction of compaction effects due to stabilisation of the grain framework by cementation. The findings of this study enhance our knowledge regarding the influence of detrital sediment composition and texture on the precipitation of early calcite and may provide implications on the impact of eogenetic carbonate in sedimentary sequences.

Theme 8. General topics in clastic sedimentology

Special Session 8.2. Analogues and experiments for understanding early diagenesis of clastic sediments

Oral presentation

An analogue study of the Ravenglass Estuary: detrital to authigenic grain coats

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Detrital clay minerals, such as chlorite and illite, are reported to coat grain surfaces in a wide range of clastic sedimentary environments. Upon burial and diagenesis, detrital grain coats and precursor minerals may become altered to form continuous authigenic grain coats, which in the case of chlorite, is known to preserve porosity and permeability (i.e., reservoir quality) by inhibiting the formation of quartz overgrowths which might otherwise fill pores. Therefore, understanding the occurrence and distribution of grain-coating clay minerals in sedimentary environments is key to predicting the occurrence of anomalously high reservoir quality in deeply-buried sandstones. Modern sedimentary environments (e.g., deltas, estuaries) can be studied as analogues for deeply-buried systems to help us understand the depositional processes that form detrital grain coats and control how they are distributed. Here we present how the Ravenglass Estuary, a modern macro-tidal in north west England, has been used as an analogue for deeply-buried reservoirs due to the presence of detrital clay grain coats in the estuarine sediment. Previous surface studies of the estuary have revealed that clay grain coats are distributed heterogeneously, and concentrated in marginal inner estuary tidal flats but almost absent in the outer estuary. In addition to surface studies, here we show how new subsurface data from 12-m geotechnical cores has improved our understanding of how depositional and near-surface post-depositional processes have influenced the distribution of detrital clay coats. Machine learning methods, based on combined geochemical (bulk XRF) and textural data, have been used to classify sub-depositional environment in the geotechnical cores from the Ravenglass Estuary, providing a framework to explore clay content, Fe-enrichment, and availability of iron: all essential for generating authigenic chlorite coats. Subsurface analogue studies allow us to project models of sedimentary environments into the eogenetic realm and discuss the implications on generation of reservoir quality-preserving chlorite coats upon deeper burial.

Theme 8. General topics in clastic sedimentology

Special Session 8.2. Analogues and experiments for understanding early diagenesis of clastic sediments

Poster presentation

Origin and controls of wood silicification in the Upper Stephanian of the south-eastern Pyrenees

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A mineralogical and petrographic study of silicified wood from the continental late Hercinian basin of Erill Castell, SE Pyrenees (Spain), has been undertaken. The basin infill comprises a succession of sedimentary and volcanosedimentary units separated by angular unconformities, and contains numerous coal seams. Plant fossils abound in the fluvial and the floodplain facies where coal seams occur, although silicified remains are rare and were found in particular beds. These remains are associated with river channel and alluvial fan deposits. Thin sections observed through optical microscopy reveal differences between samples collected in different host rock environments. Wood samples from fluvial deposits are mainly silicified by chalcedony, and later by macroquartz mosaics that replace the previous silicified wood. Host sandstones and siltstones have not undergone pervasive silicification, but are locally cemented with opal and are affected by ferruginization. They contain angular clasts of quartz and altered volcanics. The paragenesis of wood samples enclosed in a debris flow is more complex. Chalcedony remains the most abundant mineral, but it is accompanied by important amounts of other silica phases, including quartz and several generations of opal. In these samples, macroquartz is likewise associated with poorer wood preservation, whereas microquartz seems to have formed from previous opal generations. The host rock is a matrix-supported conglomerate cemented by microquartz and opal. The clasts are angular, poorly sorted (up to 30 cm) and composed of black chert and volcanics. Hence, two early diagenesis silicification pathways can be identified. We suggest that in both cases the origin of silica can be traced to eroded equivalents of the weathered felsic to intermediate volcanic rocks of the basin (through glass devitrification and feldspar kaolinization). In fluvial deposits, the silicification of wood was due to infiltration of groundwater that interacted with fresh volcanic rocks upstream. Conversely, in debris flows, interstitial fluids saturated in silica were produced by weathering of volcanic material in the sediment enclosing the wood.

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Theme 8. General topics in clastic sedimentology

General Session

Oral presentation

Petrothermal and petrophysical characterization of alluvial fan, fluvial fan and lacustrine Paleogene sediments of the Ebro Foreland Basin, South Pyrenean fold and thrust belt

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We analysed the petrothermal and petrophysical properties of the Upper Eocene alluvial fan, fluvial fan and lacustrine deposits in the NE Ebro Foreland Basin, South Pyrenean fold belt. The proximal facies located in the Oliana anticline consist of marine marls, transitional sulphates and non-marine alluvial sandstones and conglomerates. Distally, fluvial fan facies of the Sanaüja anticline, comprise channelled and crevasse splay tabular sandstones and clays interbedded with shallow lacustrine facies. Lacustrine deposits comprise channelled and mouth bar tabular deltaic sandstones, offshore carbonates and playa-lake gypsum and clays. Thermal conductivity measurements reveal low values from 1.818 to 3.232 $Wm^{-1}K^{-1}$ for the carbonates and sulphates, as well as high values from 2.831 to 3.736 $Wm^{-1}K^{-1}$ for the distal sandstones and conglomerates. The connected porosity of proximal alluvial conglomerates and sandstones range from 1.90 to 3.73% and 0.74 and 22.42%, respectively, with 64.52% of the values ranging from 0.42 to 5.25%. In contrast, distal fluvial fan and lacustrine sandstones have higher overall porosities from 3.16 to 18.02%, with 68.96% of the values between 6 and 12%. Sulphates and carbonates have porosities from 0.42 to 20%. Mineral density of the samples ranges from 2.310 to 2.409 g/cm^3 for sulphates, from 2.682 to 2.753 g/cm^3 for carbonates and from 2.618 to 2.783 g/cm^3 for conglomerates and sandstones. Velocities of compressional acoustic waves range from 2236 to 6322 ms^{-1}, showing a negative correlation with connected porosity values. Contrarily, no correlation is observed between connected porosity and thermal conductivity of the studied rocks. This finding is in contrast to the results of previous authors observations, which reported that these properties are negatively correlated.

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Theme 8. General topics in clastic sedimentology

General Session

Oral presentation

Diagenetic features of the Tunas Formation (Permian) in the Claromecó Basin (Buenos Aires province, Argentina): its implication in reservoir characterization

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The Claromecó Basin (Buenos Aires province, Argentina) has a relevant economic and energetic interest due to the presence of coal layers contained in the Tunas Formation (Permian) which might be considered effective source rock for gas resource generation. This work aims at identifying the processes that acted during the burial history of the deltaic sandstones of the Tunas Formation and their effects on the reservoir quality. To this purpose, cores samples of the Tunas Formation were analysed using a combination of petrographic (transmitted light, QEMSCAN, Cathodoluminescence) and petrophysical methods. The analysed wells are composed of sandstones interbedded with mudrocks, carbonaceous mudrocks, tuffs and coals.

Sandstones are medium- to fine-grained, framework-supported, moderate-to-well sorting, with concave–convex grains contact and 5–20% of matrix. Authigenic minerals are calcite and laumontite and minor proportions of quartz and feldspar overgrowths and clay minerals. Porosity is primarily secondary, associated with occurrence of fractures and dissolution of feldspars and carbonate cement. Porosity determined by optical and petrophysical analyses ranges from 0.1 to 4% and permeability ranges between 10^{-3} and 10^{-6} mD.

Our results point out that during early diagenesis, physical compaction and precipitation of carbonate cements are the principal factors significantly reducing the primary porosity. Furthermore, in the mesogenesis stage, chemical compaction, precipitation of carbonate and zeolitic cements and silicate overgrowths, further contribute to porosity loss. However, secondary porosity could have been produced during this phase due to the dissolution of unstable grains and calcite cements, caused by the action of acid fluids generated during the decomposition of organic matter and gas migration. Additionally, secondary porosity can be generated by fracturing, as a consequence of burial and tectonic stress and by the increase in pore pressure during the hydrocarbon generation and migration processes. In conclusion, in the Claromecó Basin, the reservoirs properties have been controlled by the composition of clasts and cements, the presence of organic-rich levels, able to generate hydrocarbons, and by the tectonic stress that acted during the burial and uplift of the basin.

Theme 8. General topics in clastic sedimentology

General Session

Oral presentation

Sedimentary features and structures of a sea level changing continental platform – NW Black Sea

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The main goal of the work is to present and decipher several types of assemblages made by sedimentary features and structures, specific for a continental platform with a high degree of sea level change during Quaternary – the NW Black Sea. The main methods employed in obtaining pertinent information regarding specific features and structures issued mainly as the result of the sea level change were multibeam echosounding, sub-bottom profiling and shallow sediment sampling. The multibeam echosounding allowed us to produce detailed Digital Terrain Models – DTM, one of the best information able to provide a synoptic view regarding the presence of specific morphological features at the level of the sea floor, that can testify the geological processes controlled by the sea level change over the shelf area. The chirp sub-bottom profiling technique allowed us to produce very high resolution (1 dm or better vertical resolution and about each 3 dm a ping) seismic cross-sections. Due to its characteristics the Black Sea evolved during Quaternary as a lake or as a semi-enclosed sea basin, being affected by high amplitude sea level variations (150 m, or even more). According with several authors during the last 25 ky BP, the sea level changed significantly at least seven times with relative amplitudes ranging from 8 0m to 5 m. The time dynamics of these changes is also highly variable. Function of the speed and amplitude of the sea level change new sedimentary features and structures were build on the NW shelf of the Black Sea, but also previous existing such features were destroyed or modified. From these features we mention: paleo-shorelines, beach ridges, terraces, river paleo-valleys and strands, marshes and deltas. As sedimentary structures we specify regressive and transgressive ones, eroded and/or accretion structures and morphologies. The NW continental platform is the widest in the Black Sea and due to its sub-aerial exposure during the glacial times, even some aeolian features and structures were build on the present mid and outer shelf.

Theme 8. General topics in clastic sedimentology

General Session

Oral presentation

Insight into the chronology of sedimentation at the Bela alluvial fan (Karavanke Mts., NW Slovenia)

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The alluvial fan of Bela with a total area of ~ 1.2 km^2 is located east of the town of Jesenice at the foot of the Karavanke mountains in northwestern Slovenia. The alluvial fan is densely populated with almost 2,000 inhabitants. The interest in research of this area is closely related to the finding that the settlement of Koroška Bela, which is built on the Bela alluvial fan, is at risk from slope mass movements, as there are several large active landslides in the hinterland. Historical data also report on the devastating debris flow in Koroška Bela in 1789. The sedimentary body deposits were investigated in five 3.4–4.1 m deep research excavations along the alluvial fan, covering its proximal, middle and distal part. Two dating methods were used to determine the age of mass flow events. Nine samples were analyzed using bulk sediment radiocarbon dating, and two samples were dated using the optically stimulated luminescence (OSL) method. Excavations revealed several successive layers of debris flow sediments, consisting mostly of clayey–silty–sandy gravels. The amount of matrix and the silt/sand/clay ratio varies between the layers. The gravel clasts are mainly angular to subrounded. The distribution of clasts indicates reverse gradation in some layers, but distinct sedimentary structures are not evident. Individual thick gravel layers are generally covered by thinner, 5–40 cm thick layers or lenses of laminated silty sands interpreted as deposits of fluvial processes that followed major mass flow events. The layers associated with individual large events are 25 to 160 cm thick, attesting to the great magnitude and range of debris flows. In the distal part of the fan, sandy silt and clay with gravel occur in the uppermost layers, which were deposited as sediments of mudflows with a different material origin from debris flows. Radiocarbon ages indicate that the oldest four sampled sediments were deposited during or shortly after the Last Glacial Maximum, the four youngest events in the two proximal excavations belong to the Holocene, and the youngest dated sediment belongs to the historical event. One radiocarbon age mismatch with its stratigraphic position, which we attribute to resedimentation of previously deposited older sediments along the alluvial fan. OSL ages agree relatively well with radiocarbon ages.

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General Session

Oral presentation

Shale facies characterization as a determining factor for the assessment of CO_2 plume and pressure footprint

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CCS workers have adopted tools and methods of reservoir production physics that have suffered some limitations for the determination of CO_2 capacity–containment–injectivity by simplifying the flow properties of the rocks, most notably the sealing lithotypes. This paper discusses the importance of Shales facies, as the most important sealing lithotypes, within a geological system, to aid in the assessment of CO_2 and pressure/brine flows. Chief among these properties are permeability and capillary threshold pressure. In the subsurface, they are dictated by the depositional environment, lithological contents, and geological processes.

Analyses of samples from different depositional settings reveal strong relationship between shale facies and sealing character. Silt-poor well-laminated shales generally have excellent to exceptional sealing behaviour. Increased percentages of silt-sized detrital grains enhance preservation of relatively large diameter pore throats, thereby lowering sealing capacities. Sub-parallel-alignment clay minerals and organic matter and early marine carbonate cementation can significantly enhance sealing capacity. Bioturbation generally degrades sealing capacity. Mudstones associated with proximal channel–levee complexes commonly exhibit highly deformed fabrics and are moderate to very silty and consequently have relatively low sealing potential.

Shales are effectively perfect seals with respect to multi-phase flow (e.g. hydrocarbons, CO_2), but open with respect to single-phase flow, allowing for pressure dissipation. The multi-phase CO_2 flow is governed by the Young–Laplace physics with capillary threshold pressure as the chief property, while the single-phase pressure flow is governed by darcy's law with permeability as the chief property. The correlation between capillary threshold pressure and permeability suggests that an assessment of CO_2 storage effectiveness should consider the interplay between these different attributes in the numerical assessment. A case study using seismic facies for the analysis of the storage facies architecture and as the base of the 3D high-resolution fluid model, will be presented. We are calling for a paradigm change of CO_2 storage from petroleum production engineering heuristics to a more geologically driven one.

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General Session

Oral presentation

A 125-million-year-old mystery: what killed the *Hypsilophodon*? A sedimentological investigation into the genesis of the Hypsilophodon bed (Wealden Group, Isle of Wight)

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The Hypsilophodon Bed is a 3m-thick layer of mudstone, siltstone and sandstone located at the top of the Wessex Formation (Early Cretaceous, Barremian) on the southwest coast of the Isle of Wight, England. Large numbers of skeletons from the small bipedal dinosaur *Hypsilophodon foxii* have been recovered from the bed since the mid-1800s. Previous theories for these fossil occurrences have focused on mass death events including miring and flood-related mortality. However, no detailed sedimentological study has been conducted on the horizon and consequently its depositional environment is unclear. Furthermore, information regarding the location of historic fossil finds is lacking, which combined with significant coastal erosion and a scarcity of recent finds means our ability to evaluate differing hypotheses for the fossil assemblage is restricted. Here, we undertake a comprehensive sedimentological study of the bed to constrain its depositional environment with methods including sedimentary logging, drone imagery, palynology, petrographic and microfossil analysis. Examination of the matrix of *Hypsilophodon* fossils in museum collections has been carried out to identify where they are located within the bed. Results reveal a river floodplain which became permanently waterlogged, forming firstly a marsh and then muddy tidal flats as relative sea level rose prior to the establishment of a lagoon which deposited the overlying Vectis Formation. *Hypsilophodon* fossils are found to be both spatially and stratigraphically widely distributed and display a range of levels of articulation, completeness, and preservation, suggesting the fossil assemblage is not the result of a single mass death event but instead resulted from a time-averaged accumulation of carcasses. The Hypsilophodon Bed lies at the boundary between the fluvial red-bed sequence of the Wessex Formation and the overlying lagoonal mudstones of the Vectis Formation. Consequently, detailed investigation of the bed also provides new insight into the nature of the transition between the two formations.

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General Session

Oral presentation

Reactivity of glauconitic clasts during burial diagenesis

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Palaeogene glauconitic sandstones in former hydrocarbon fields, Siri Canyon, Danish North Sea, are targeted for CO_2 storage. The sandstones contain up to 25–35% glauconitic clasts, which change mineralogically and chemically during burial diagenesis. The sandstones were deposited as gravity flows interbedded with hemipelagic mudstones and marl. With burial depths ranging from 1600 m to 3000 m they provide the perfect opportunity to investigate the effect of burial diagenesis. The reactivity of glauconitic clasts during burial diagenesis will help explore their likely reactivity during CO_2 storage. A combination of methods (optical and scanning electron microscopy, X-ray diffraction, X-ray fluorescence) was applied to document petrographical, mineralogical, morphological and chemical variations with burial depth. The chemical composition of glauconitic clasts was visualized by automated quantitative mineralogy. The framework grains in the sandstones are mainly quartz, common glauconitic clasts, minor amounts of K-feldspar, and rare mica, rock fragments and heavy minerals. Glauconitic clasts consist of mixed-layer glauconitic mica/Fe-smectite, which shows decreasing abundance of expandable (smectite) layers with increasing burial depth. 'Illitization' of mixed-layer glauconitic mica/Fe-smectite in the glauconitic clasts gradually develops during burial (down to 2500 m), whereas chloritization of glauconitic clasts occurs in the deepest (2800–3000 m) and most distal settings. Water generated from clay mineral transformation in the Tail End Graben is suggested to be responsible for the low salinity formation water. The reduced salinity probably led to expansion of the smectitic layers and consequently opening of the microporous structure in the glauconitic clasts resulting in disintegration and enhanced chloritization. The reactivity of glauconitic clasts is slow due to their microporous structure, however this can be enhanced if the surrounding environmental conditions are changed. The impact of changes in formation water chemistry must be evaluated carefully when dealing with glauconitic sandstone reservoirs.

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General Session

Oral presentation

Characteristics and controlling factors of mixed deposition in saline lakes: a case study of Lower Ganchaigou Formation in the Western Qaidam Basin

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The distribution pattern and forming dominant factors of mixed deposition were studied, based on the analysis of rock mineral composition, layer combination characteristics and cause type. The method used in this study include regional geological data analysis, logging data analysis, core observation and description and Indoor sample analysis. It was considered that the lacustrine mixed deposition has the characteristics of multi-component mixed and multi-type overlapped, and the input of source and climate in the lacustrine environment of relatively shallow water were the main factors controlling the mixed deposition. The results shows that, the mineral composition of mixed deposition were mainly terrigenous debris (average mass fraction is 40.93%), carbonate (average mass fraction is 44.82%) and salt minerals (average mass fraction is 7.91%). The composition types of mixed were mainly the mix of mud and carbonate within the fabric, Thin interlayer of fine debris and carbonate, Thin interlayer of fine debris and salt minerals, the mix of algae (algal layer and algae clumps) and terrigenous debris. The cause types of mixed deposition include gradually changed, Mutational changed (type I and type II) and original position. The proportion of gradually changed mixed deposition was 80–85%. Original position mixed deposition was mainly the mix of algal limestone, algae dolomite and terrigenous debris the proportion of original position mixed deposition was about 8–10%. The type I of mutational changed mixed deposition was about 5–8%. Shallow Lake were main facies zone of thin interlayer mix deposition, semi-deep lake were main facies zone of mix deposition within the fabric, the beach and bar of shallow Lake and underwater bulge were main facies zone of mix deposition related to algae. Paleotopography controls the development of mixed sediments by influencing provenance supply and sedimentary hydrodynamic conditions. Differences in chemical conditions and sediments at different water depths lead to differences in the distribution of mixed sediments. Sedimentation of underfilled lake in the Qaidam Basin in the Paleogene led to continuous climatic drought, which in turn resulted in extensive salt mineral deposits.

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General Session

Poster presentation

Increasing reservoir predictability by reducing uncertainty by using machine learning analytics with forward stratigraphic simulations

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The innovative workflow presented in this abstract is based on the principle of using machine learning analytical workflows conditioned to forward stratigraphic modeling to make better predictions on reservoir characterization hence decreasing the overall uncertainty on reservoir properties. It is also important to highlight in this abstract that the extended value proposition highlighted by the integration of blind testing validation on the training targets helps in understanding areas of specific uncertainties and low correlation coefficient data points. The work presented in this abstract highlight the new significance of using property analytics for making predictive models for Oil and Gas reservoirs and reservoir properties like porosity, and saturations and deriving net-to-gross estimations for reservoir levels which are being conditioned to several seismic inputs and later forward modeling. The value in the workflow is by integrating forward stratigraphic modeling into the results as training features in which predictive sediment properties are used to make correlations with the reservoir properties through the integration of decision trees being generated from the input datasets which are being referred to here as the training targets and the conditioning datasets which are the training features. The work shows a correlation coefficient improvement in the range of 12 to 16% for all the integrated cases of forward stratigraphic modeling with machine learning property analytics as compared to the isolated cases of using single machine learning training targets without forward stratigraphic modeling outputs. The innovative workflow presented in this abstract shows the significance of using machine learning property analytics as compared to geostatistical algorithms which give better insights into the understanding of uncertainties and improve the predictability of reservoir properties. The workflow has shown further improvements in predicting reservoir properties by the integration of forward stratigraphic simulations, a 50%-time reduction is observed between modeling reservoir properties through geostatistical workflows by creating variograms, vertical proportion curves, and probability curves with a range of model predictability improving to a maximum level of 20%.

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General Session

Poster presentation

Analysis of the controls on thermal properties in the Sant Llorenç del Munt distal fan-delta complex, eastern Ebro foreland basin

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This study aims the characterization of the sequence stratigraphy, mineralogy and thermal properties of deltaic deposits. As a case of study, we focused on the transgressive sequence set of the middle Eocene Cal Padró composite sequence of the Sant Llorenç del Munt fan-delta complex in the eastern Ebro foreland basin, related with the growth of the Catalan Coastal Ranges and the Pyrenees. The Cal Padró composite sequence resulted from the stack of fundamental high-frequency sequences, which arranged in 3–80 m thick transgressive and regressive system tracts made of: 1) delta plain channelled sandy–conglomeratic bodies, tabular sandstones and red mudstones; 2) delta front massive, tabular or cross-bedded conglomerates and coarse to fine-grained sandstones; 3) slope/prodelta marlstones, fine to medium tabular sandstones and poorly-sorted conglomerates; and 4) mixed shelf sandy marlstones, nummulitic, bivalve and echinoid packstones and coral and red algae accumulations restricted to transgressive systems tracts. Powder X-ray diffraction analyses of 22 samples indicate that they are composed of variable contents of quartz, calcite, dolomite, phyllosilicates and feldspars. Thermal conductivity measurements indicate that this parameter is controlled by the contents in calcite, dolomite and quartz. Delta plain sandstones and conglomerates display high conductivity values from 3.861 to 4.411 $Wm^{-1}K^{-1}$, whereas delta front sandstones and conglomerates show much more scattered values from 2.353 to 4.374 $Wm^{-1}K^{-1}$. Slope sandstones and mixed shelf carbonates have conductivities from 3.383 to 4.849 $Wm^{-1}K^{-1}$ and from 2.530 to 2.857 $Wm^{-1}K^{-1}$, respectively. Most of the lower conductivities are measured in transgressive sediments. However, more analyses are necessary to uphold these conclusions.

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General Session

Poster presentation

Polygenetic soil development in glacial till during the Vistulian stage, Poland: evidence from heavy mineral analysis

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Preliminary analysis of heavy mineral suites from soil profiles in glacial till showed polygenetic development of soils in areas not glaciated during the Vistulian glaciation. The analyzed samples showed significant variability in the frequency of individual heavy minerals, which were particularly well marked by the applied indices: ZTR (zircon–tourmaline–rutile maturity index), GZi (garnet–zircon provenance-sensitivity index), ATi (apatite–tourmaline provenance-sensitivity index). High-resolution heavy mineral analysis (HRHMA) showed variability in the degree of weathering and rounding of minerals from modern and fossil soil levels. The difference is also emphasized by the occurrence of tourmalines, apatites, and zircons with different colors, morphologies, and displayed pleochroic patterns. Differences in the genesis of soil levels are particularly well illustrated by the weathering microstructures observed on hornblende grains. Amphibole grains do not show a logarithmic relationship between the degree of weathering and depth, indicating that part of the soil levels has been inherited from older Quaternary deposits. Hornblende grains display the multi-stage development of weathering structures, both in currently identified soil levels and also in soils inherited from earlier weathering cycles. In each cycle, the deepening of developing microtextures occurred as a result of chemical weathering, accompanied by a mechanical rejuvenation of mineral grain surfaces through crushing or in situ mechanical weathering. Unchangeably important stages in the development of soils in the studied area were the periods when periglacial conditions were in operation during the Vistulian Stage. This resulted in the accumulation of fluvioglacial sands that covered the area and tightly filled the formed frost cracks. Consequently, the frost cracks filled by sand formed geochemical corridors that supported the drainage system of poorly diversified glacier highlands.

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General Session

Poster presentation

Sedimentological evidence of climatic changes during the Miocene Climatic Optimum in the North Croatian Basin (SW Pannonian Basin System, Croatia)

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The North Croatian Basin (NCB) occupies the south-western part of the Pannonian Basin System, and belongs to the Central Paratethys realm. Detailed sedimentological field studies and mineralogical and petrological analyses showed that a 40 m thick section composed of well-bedded mixed, carbonate–siliciclastic deposits with occurrence of pyroclastics indicate three evolutional stages of lake development. The first evolutionary stage evolved in the late Early Miocene. It was characterised by mainly dolomite precipitation directly from the water body, and are associated with tuffites and marls, together with minerals such as analcime, hydrous Ca-bearing magnesium carbonate, and natrolite. This indicates deposition in a shallow, hydrologically closed lake of highly alkaline waters controlled by an arid climate. The second evolutionary stage is represented by the intercalation of dolomites and sandstones, indicating changes of hydrologically open and closed lacustrine environments as result of the frequent alternation arid and humid climates. The third stage, characterized by deposition of siliciclastics by gravity flows indicates the formation of a long-lived, hydrologically open lake that probably commenced in the Middle Miocene. The whole investigated lacustrine depositional sequence coincides with the Miocene Climatic Optimum generally characterized by hot and warm, and humid climates. However, the evolution of the closed lake that is correlative with similar lakes in northern Bosnia and central Serbia, indicates the existence of an arid zone in the region that was confined by areas characterized by a more humid climate in the late Early Miocene.

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General Session

Poster presentation

The Badenian/Sarmatian environment on the edge of the Pannonian Basin System

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The Badenian/Sarmatian succession of Hrvatska Kostajnica, exposed due to a landslide on the eastern slopes of Kubarnovo brdo hill, was investigated for its sedimentological and paleontological features. Marly sediments from the newly formed outcrop originated from the southwestern marginal part of the Pannonian Basin System (PBS), which was one of the back-arc basins of the Mediterranean. The PBS had a quite vivid tectonic and depositional history characterized by establishing and losing connections with the Mediterranean Sea and the Indo-Pacific Ocean on several occasions. The transition from the syn-rift phase to the post-rift phase in the PBS occurred in the Late Badenian. In the earliest post-rift phase, during the Sarmatian, environmental variations were the result of local tectonics, which had a significant role in controlling sedimentation. Continuous deposition from the Late Badenian to the Early Sarmatian resulted in structureless marls dominating the succession with a single layer of clayey limestone, marking the Badenian/Sarmatian boundary. This succession was deposited in an offshore marine environment with the occasional input of terrigenous material. Carbonates (calcite and aragonite) and clay minerals are dominant in marly sediments, while quartz and plagioclase are less abundant. In most samples, zeolite minerals (clinoptilolite/heulandite series) are present in a small amount. Among clay minerals, smectite and Illite/muscovite are the most abundant. Re-deposition of volcanic material from older formations such as tuffs is the source of smectite and zeolites. Paleoenvironmental changes in the studied succession can be reconstructed using microfossils. The lower, Badenian part of the succession was deposited in a shelf environment with variable oxygen concentration and occasional terrigenous input. Microfossil assemblage from the thin layer of clayey limestone points to stressful and unfavorable environmental conditions at the Badenian/Sarmatian boundary. The upper, Sarmatian part of the succession was deposited in a marginal marine environment. Correlative Sarmatian successions across the PBS, however, show greater environmental variability during this period, ranging from shallow-water hyposaline to deep-marine environment.

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General Session

Poster presentation

Shape, volume-to-area ratio, and settling-velocity models for siliciclastic, carbonate, volcanic and plastic particles and their sedimentary implications

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The settling velocity of sediment particles is a key hydrodynamic parameter, expressing a balance between gravity and fluid drag as grains sink through water. Settling velocity exerts a direct influence on advection length in turbidity currents and also provides insights into sediment entrainment thresholds. The prediction of settling velocity has long been a research topic that requires representation of the size, density and shape of sediment grains. However, natural sediment has significant variability in these parameters, and measurement techniques are not standardized, and sometimes haphazard. To address these issues, we have compiled the so far most extensive literature database that contains shape statistics and settling velocities of siliciclastic, carbonate, volcanic, and plastic particles (ca. 50 datasets, n = 5,000 grains). Only datasets for which the short, intermediate, and long axes were measured for each individual particle have been included, because these dimensions are required for the determination of a particle-shape parameter. Many datasets also contain measured maximum projection areas, volumes, and densities. Large discrepancies exist between measured and calculated parameters for datasets of different composition, but also for datasets of the same sediment type. These properties greatly affect settling velocities, which complicate prediction of sediment distribution using forward stratigraphic models. The simplification that sediment grains can be modelled as spheres, is generally far from being valid, and irregular grain shapes can strongly affect settling velocity and thus sediment transport. Using a newly collected dataset consisting of high-resolution micro-CT scans and settling experiments, we demonstrate how modern grain measurement methods can reconcile issues with classic datasets. We conclude that measuring axis dimensions alone is not sufficient, but neither is determination of the maximum projection area. Measurement of both the particle volume and maximum projection area are crucial to obtain the data necessary to correctly parameterize the size, shape, and settling velocity of particles. Only with these data can we correctly constrain the relevant particle dimensions for predictive modelling purposes.

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General Session

Poster presentation

Ordovician–Silurian and Devonian sedimentary complexes of Mendeleev Rise, Wrangel Island and Chukotka and their correlation (Russian Arctic)

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There are great similarities in the Paleozoic (O3-S and D2-3) units of Chukotka, Wrangel Island and Mendeleev Rise: synchronous intervals without sedimentation, similar composition of sandstones and general facies patterns. During the studied stratigraphic intervals, shallow water environments are established – carbonate sedimentation for Ordovician–Silurian and terrigenous for Devonian. In Silurian stage, shallower facies were located in the East both for the Mendeleev rise and for Wrangel Island, which is also confirmed by the transport direction. In the Devonian, there is a terrigenous type of sedimentation with a similar composition of sandstone both on the Mendeleev uplift and on Wrangel Island and Chukotka. Transport direction has been established from North to South for the Chukchi region. The stage of the Ellesmere deformations in the Early Devonian is recorded by absence of deposition on the Mendeleev rise and the accumulation of quartzite sandstones in shallow water environments on Wrangel Island and more deeper ones in Chukotka, which indicates a peneplenization and the weathering crust forming on the adjacent land. For the Upper Devonian, a parent source probably represented by a series of islands composed of granitoids and meta-sedimentary rocks, because the synchronous sandstone's composition varies in different sections of Wrangel Island and Chukotka.

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General Session

Poster presentation

Diagenesis, diagenetic facies and their relationship with reservoir "sweet spot" in low-permeability and tight sandstone: Jiaxing area of the Xihu Sag, East China Sea Basin

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The optimization of reservoir sweet spot is the key to efficient exploration and development of low-permeability and tight sandstone gas reservoirs. However, offshore deep low-permeability and tight sandstone has the characteristics of large burial depth, large diagenesis heterogeneity and prominent importance of diagenetic facies, which makes it difficult to predict reservoir sweet spot. This work comprehensively used logging data, conventional core analysis, thin section, powder particle size analysis, clay x-ray diffraction analysis, cathode luminescence analysis, scanning electron microscopy and energy spectrum analysis, and carried out the study of diagenesis, diagenetic facies and reservoir sweet spot of low-permeability and tight sandstone of H3 and H4 members in Jiaxing area of Xihu Sag. The results show that the H3 and H4 sandstones were divided into five diagenetic facies, and chlorite-coated facies and dissolution facies were favorable diagenetic facies belts. The H3 member mainly develops chlorite-coated facies, dissolution facies and quartz-cemented facies, whereas the H4 member primarily develops quartz-cemented facies and chlorite-coated facies. The percentages of type I sweet spot, type II_1 sweet spot and type II_2 sweet spot in the H3 reservoir are approximately 21%, 23% and 26%, respectively, whereas the percentages of type I sweet spot, type II_1 sweet spot and type II_2 sweet spot in the H4 reservoir are about 16%, 15% and 16%, respectively. The distribution rules of reservoir sweet spot were investigated. Type I sweet spot was mainly developed in the areas of chlorite-coated facies and dissolution facies of medium sandstone and coarse sandstone in the channel bar and braided channel sedimentary microfacies. Type II sweet spot was primarily distributed in the areas of quartz-cemented facies, chlorite-coated facies and minor dissolution facies of medium sandstone, fine sandstone and sandy conglomerate in the braided channel, subaqueous distributary channel and channel bar sedimentary microfacies. Type III sweet spot was mainly developed in the areas of tightly compacted facies, calcite-cemented facies and quartz-cemented facies of fine sandstone, siltstone and a small amount of sandy conglomerate in the subaqueous distributary channel sedimentary microfacies.

Theme 8. General topics in clastic sedimentology

General Session

Poster presentation

Study on the evolution and distribution of lacustrine sediments in the narrow intermountain basin – Jurassic of Shengbei Depression in Tuha Basin as an example

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Turpan Hami Basin is an intermountain basin between the Junggar Basin, Tarim Basin and Qaidam Basin in western China, and its Jurassic sedimentary system is complex. Shengbei sag in the basin is rich in oil and gas resources, which is the focus of lithologic exploration in recent years. In order to determine the generation, migration, reservoir series and location of Jurassic oil and gas in the sag, it is necessary to carry out detailed sedimentary evolution research to determine the spatial distribution of coal and sand beds. This study adopts a large number of drilling cores, geological outcrops and seismic data, combined with modern typical sediments, starting from ancient landforms, through heavy mineral assemblages and rock composition analysis, to determine the source directions, and uses multi-well analysis, seismic sedimentary research methods, especially seismic facies, isochronous stratigraphic slices and other technologies to depict the distribution and evolution of sediments. Thus, the evolution process of the Jurassic inherited shallow braided river delta in Shengbei sag is described, and the distribution characteristics of coal seams and sand layers in the depression are also described. This study, aiming at the complex ancient landform in the mountains, uses the seismic sedimentary method, combined with the traditional sediment analysis ideas, to describe the process of sediment evolution in detail, which has certain reference significance for other similar lacustrine sediment research.

Theme 9. Volcaniclastic deposits

Special Session 9.1. Volcanism and sedimentology

Oral presentation

Prediction of volcanic facies in Liaohe Basin using multi-label ensemble learning

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Liaohe Basin is located in the northeast of Bohai Bay Basin. Since Cenozoic, tectonic and magmatic activities have led to the great differences of volcanic rocks in this area. The complex lithology and lithofacies of volcanic rocks pose a challenge to the sedimentological study in this area. The data optimization method combined with multi-Grained Cascade forest was used to predict lithology and lithofacies using nine kinds of conventional logging of the eastern sag of Liaohe Basin. Firstly, K-means and SMOTE are used to optimize the imbalanced conventional logging data set, then multi-Grained Cascade forest with process optimization is used for model training. We introduced multi-view evaluation metrics for multi-label classification. A simulated well was then built to compare the model with the CF, AdaBoost, RF and SVM. Finally, the model is applied to the actual stratum. The results show that the proposed method has advantages and application value in multi-label prediction of igneous lithology and lithofacies. This provides reference value for the study of volcanism and sedimentology in Liaohe Basin.

Theme 9. Volcaniclastic deposits

Special Session 9.1. Volcanism and sedimentology

Oral presentation

Complex terrestrial sedimentary systems associated with mature intracontinental monogenetic volcanic fields of Saudi Arabia

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About ten major volcanic fields are distinguished along the western Arabian Peninsula covering an area of about 80,000 km^2, among the most prominent Saudi fields are the Ithnayn, Khaybar and Rahat fields are those that showing evidence of Holocene volcanic activity. The Khaybar and Rahat volcanic fields share the common feature to have volcanics fed from the full spectrum of mafic to silicic magmas and been producing volcanic landforms more associated with polygenetic volcanism such as lava dome, silicic tuff rings and extensive block-and-ash fans. Volcanic fields in the south commonly erupted in large alluvial fans in explosive phreatomagmatic style providing complex volcaniclastic fan architectures. In similar way, in the northern margin of the Arabian Shield, Harrat Hutaymah is the monogenetic volcanic field where eruptions occurred in an intramountain region producing complex volcaniclastic facies architecture of intra-maar and inter-edifice zonation. As climate variations occurred frequently since the Late Pleistocene, experiencing at least 21 pluvial periods in the last 1.1 Ma and a wet period within the 7 to 5 ka time spans, these fields provide an exceptional sedimentary record to understand the monogenetic field interaction with terrestrial geoenvironment. As most of the monogenetic volcanic fields produced large volume of lava flows of pahoehoe to aa types with abundant transitional flow varieties captured either within Neoproterozoic basement ridges or shallow undulating landscapes of weathered older lava flow fields we can demonstrate the interaction between these flows and the arid terrestrial environment. Applying satellite and digital terrain model analysis we can provide evidence that major artery of tube fed as well as rubble lava flows act as hydrologically active zones interacting with the host wadi networks. The December 2022 to January 2023 wet period of most of the region showed that such artery lava flow lobes act as a "sponge" and successfully able to deliver water and remobilize autoclastic lava fragments as well as pyroclasts in large distances forming complex terrestrial fan zones.

Theme 9. Volcaniclastic deposits

Special Session 9.1. Volcanism and sedimentology

Keynote lecture

Interaction between basement fault, volcanism and overlying basin fills on an active volcanic continental margin

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Based on continuous coring data drilled through the entire basin pack sequence from the top sedimentary cover to the bottom of the metamorphic basement in the Songliao Basin of northeast China, this paper demonstrates interaction between basement fault, volcanism and overlying basin fills on an active volcanic continental margin of the eastern margin of the Eurasian plate during the Cretaceous. The basements of the basin have long been considered to be the association of the Carboniferous–Permian fold system. However, the drilling results show that It is a double-layered basement composed of the Triassic–Paleozoic rocks with Carboniferous missing. It is indicated that the top interface of the Triassic basement is the rift onset unconformity (ROU). It indicates that there was a long period of compressional Uplift and denudation interval of 124.2 Ma from 242.4 to 118.2 Ma before the first cover of a Cretaceous volcanic ash sediment was deposited. Below the bottom interface of the Triassic is the Paleozoic metamorphic core complex. The interfaces not only control characteristics of the metamorphism and deformation of rocks in the past, but also control the present stress state. In situ stress measurements demonstrated that the stress state differs markedly between the upper and lower zones of the Triassic strata. In the upper section, the maximum principal stress, $\sigma1$, is nearly vertical; in contrast, it is nearly horizontal in the deeper section. It can be concluded that the increasing metamorphism and deformation with depth are stress-controlled. The unconformity interface between the Triassic and Paleozoic within the basement successions is the brittle–ductile transition boundary of rock deformation. Earthquakes mostly generate below the interface. A super long-lived volcanic conduit system of 140 Ma (from 242 Ma to 102 Ma) was developed in the center of the SLB. The interaction between basement fault and volcanism may have played a major role in the initiation and following subsidence of the SLB in the Cretaceous.

Theme 9. Volcaniclastic deposits

Special Session 9.1. Volcanism and sedimentology

Oral presentation

Study on sedimentary succession and basin filling characteristics of the Late Permian volcanic rocks: an example of the Sichuan Basin

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As a product of mantle plume activity, Permian Emeishan Large igneous province is widely distributed in Sichuan Basin. Previous studies have shown that uplifting mantle plumes can usually cause large-scale crustal uplift and the formation of dome-like uplift features, and control regional paleogeographic pattern and sedimentary facies distribution. This study constrains the temporal sequence of different regions and types of volcanic rocks in the Permian Emeishan Large Igneous Province. It combines the spatial distribution patterns of different types of volcanic rocks, paleogeomorphology and eruption environment before eruption, reduction of volcanic eruption to build process, established above the cycle and lower cycle of two major eruption, cycle of four stages of the volcano-sedimentary succession description. From the bottom up, the mantle plume in the first phase began to rise, creating a tectonic pattern of uplift and depression during crustal movement. The uplifted areas were subject to weathering and denudation, while the deeper and depressed areas were covered by seawater. Early in Stage two strong volcanic eruptions and overflows interacted to form submerged pillow lava and igneous interbedded rocks or submerged igneous rocks. In the later part of Stage two, large static overflows took place, building up a huge thickness of basalt. Early Stage three is characterized by localized ephemeral submarine volcanic eruptions in Jianyang and other areas; late Stage three localized onshore neutral volcanic debris accumulation with minor basaltic development. Stage four tuffs are widely distributed and continuously exposed to dissolution, forming weathering crusts that provide the material basis for the formation of volcanic reservoirs.

Theme 9. Volcaniclastic deposits

Special Session 9.1. Volcanism and sedimentology

Oral presentation

Geochemical characteristics of Late Jurassic–Early Cretaceous lamprophyres in western Songliao Basin, NE China: implications for lithospheric evolution

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In terms of the evolution of the lithosphere in the area extending from the Songliao Basin to the Great Xing'an Range in northeast China, the common concept is that the lithosphere in this area was thinned from the Late Jurassic through the Early Cretaceous. We discovered, however, a thickening episode in the long-term thinning background. A series of lamprophyre dikes have been recently found in the Tuquan Basin of western Songliao Basin. They were subsequently dated at 156.0 ± 2.3 Ma, 132.9 ± 1.2 Ma, and 126.2 ± 2.5 Ma, respectively, using the zircon U–Pb technique. The Late Jurassic lamprophyre was found to consist primarily of biotite and orthoclase and was thus referred to as the biotite orthoclase lamprophyre (BOL), while the Early Cretaceous lamprophyres were determined to predominantly comprise quartz and magnetite as accessory minerals in addition to biotite and orthoclase and were thus called the quartz magnetite lamprophyre (QML). The lamprophyres originated from the partial melting of enriched lithospheric mantle that had been previously metasomatized by subduction-related fluids. The BOL has high ratios of Rb/Sr (0.42) and K/Yb*1000 (28.3), and low ratios of Ba/Rb (13.5) and Dy/Yb (2.35), suggesting a magma derivation from high degree partial melting of phlogopite-bearing lherzolite mantle in the spinel–garnet transition zone at a depth about 60 km. In comparison, the QMLs have low ratios of Rb/Sr (0.02–0.06) and K/Yb*1000 (8.13–19.73), and high ratios of Ba/Rb (17.6–42.6) and Dy/Yb (3.48–4.09), indicating that the magmas were derived by low degree partial melting of lherzolite mantle in the garnet zone at a depth of ca. 85 km. In addition, the younger QML (126.1 ± 4.8 Ma) has lower Dy/Yb ratio (3.48–3.92) than that of the older QML (132.9 ± 0.97 Ma) with Dy/Yb ratio of 4.09, implying that the younger magma was produced at a shallower mantle depth (<85 km) than that of the older one. These results indicate that in the period of 156–132 Ma, the lithosphere in the study area thickened by approximately 25 km at a rate of approximately 1.0 km/Myr. The authors of this paper accordingly proposed a new geodynamic evolution model of three stages during 156 Ma to 126 Ma in NE China.

Theme 9. Volcaniclastic deposits

Special Session 9.1. Volcanism and sedimentology

Poster presentation

Wind influence on volcanoclastic deposits of 2021 eruption in La Palma (Canary Islands)

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The volcanic eruption of Cumbre Vieja in the La Palma (2021) is located on the western flank of the Cumbre Vieja and Cumbre Nueva Ridges, a mountain range of volcanic origin that crossed the island from N to S. For 85 days of the eruption it was emitting tephra in the central part of the island, only reaching the entire island of La Palma during the finer ash emissions. The volcanoclastic deposits of the eruption are mainly composed of lapilli and ash, while the bombs are practically confined to the scoria cone. The study of several volcanoclastic series around the scoria cone shows sedimentary differences depending on the dominant winds. The largest accumulation of tephras was deposited on an area trending NE–SW with respect to the volcanic cone. This sedimentary anisotropy is due to the type of tephra emission and its relationship with the trade winds and local wind. During the eruption, trade winds from the NE predominated; consequently, the largest thicknesses of the total tephra blanket are located to the SW of the cone, reaching over 4 m in some sites due to local effects of wind acting against natural and man-made obstacles. Regarding the tephra granulometry, the biggest grain sizes are also observed and the dispersion extends further from the cone. It is also where the biggest grain size of tephra, with poor selection and reworked material is observed. In addition, processes of erosion or non-sedimentation were produced when changes in the direction of the wind happened. So, soft inclined cross-bedding is frequently observed. On the NE margin of the cone, the thicknesses reach 1.5 m. The dispersion was low because the wind periods from the S and SW were less frequent. Besides, the Cumbre Vieja Ridge acts as a parapet that does not extend to the NE. In this area, it is observed a very good selection of the tephra grain size because the biggest grains depend less on the wind direction. During the periods when S and SE winds were predominant, the mixture of lapilli and ash occurs, although those events were not frequent and they had a short duration. Thus, non-deposition surfaces were also formed, with small bases of erosive layers due to remobilization processes. In conclusion, in order to have a continuous record of the processes that occurred during the eruption of La Palma, it is necessary to study several series on both the SW and NE margin.

Theme 9. Volcaniclastic deposits

Special Session 9.1. Volcanism and sedimentology

Poster presentation

Latest Triassic active eolian dune field preserved by CAMP lava flow

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The Central Atlantic Magmatic Province (CAMP) is a Large Igneous Province (LIPs) related to the opening of the Central Atlantic Ocean. One of CAMP's records in South America are the volcanic deposits found in the Parnaíba Basin, Brazil. The interaction of lava flow with active depositional systems allows the reconstruction of the paleoenvironmental and paleoclimatic conditions contemporary to volcanism. In the Parnaíba Basin, the Middle to Upper Triassic interval contains an expressive eolian succession named Sambaíba Formation, which is overlaid by lava the Jurassic Mosquito Formation, a CAMP-related volcanism, settled up at the Triassic–Jurassic boundary (T–J ~201 Ma). The basal portion of this unity records several complex eolian strata composed of successive sets of cross-stratification, frequently showing soft deformation structures. Stoke's surfaces occasionally occur, but subaqueous deposits are rare. The presence of Stoke's surfaces combined with the scarcity of subaqueous facies suggests a water table positioned close to the depositional surface, which is corroborated by the frequent soft deformation structures affecting the aeolian cross strata. The contact between the basal and upper portion of Sambaíba is a regional surface, probably representing a supersurface. The upper portion of the succession is represented by a large set of compound cross-stratification, covered and preserved by lava flow, including the preservation of the wind-rippled topset of the eolian dunes. The paleodune stoss side preserves several features of interaction between unconsolidated sediments and pahoehoe's lava flows. This study is one of the rarest reporting the preservation of both aeolian dune topsets and lava imprint features by lava floods covering an active dune field, preserving the bedforms morphologies. The paleocurrent to NW of the aeolian dunes suggests that trend winds prevailed in the low latitudes of Gondwana at the Triassic–Jurassic boundary, supporting the numerical atmospheric models for the period. Moreover, the data reported in our study provides more evidence about the aridity at low latitudes in western Gondwana for the Triassic period. Finally, the interaction between sediment and lava indicates that the upper portion of Sambaíba Formation can reliably be positioned at the T–J boundary.

Theme 9. Volcaniclastic deposits

Special Session 9.1. Volcanism and sedimentology

Poster presentation

Preliminary studies of the volcanic and volcanoclastic sequences of the south–central coast provinces of Vietnam, including the Ly Son Island (Neogene; South China Sea)

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Since the mid-Pliocene, East Asian climates have experienced significant changes. One view suggests that the uplift of the Tibetan Plateau during this period could have been responsible for these dramatic changes, while some other authors attribute these changes to the ongoing global cooling. In such a broad scientific discussion, the regional effect of active volcanism should be considered. The studies focused on the detailed recognition of Neogene volcanoclastic series deposited in the area related to the Song Ba continental rift. It is associated with volcanoes and differentiated terrestrial environments, e.g. lakes and rivers. Volcanic activity and parallel accumulation of terrestrial deposits caused pure basalts are associated with the thick series of volcanoclastic and terrestrial sediments. Field studies were preceded by topographic and morphotectonic analyses based on the SRTM digital elevation model. During field research, classical sedimentological description of exposures, analysis of textural and structural features, construction of high-resolution lithological sections, measurement of magnetic susceptibility, measurement of directional structures, photographic documentation and collection of samples were done. Studying such series may supply answers to many crucial questions, including what was the type and duration of the volcanic activity, did volcanism influence the environment of the nearby lakes, did changes in water chemistry influence the changes in the biotic lake assemblages, did the type of deposit depend only on volcanic processes or also on the weathering and erosional processes in this part of Asia. Answers to these questions are the main scientific goals of our studies. Moreover, the continuation of the Song Ba rift is located on the shelf of the South China Sea, and the large Phu Khanh, Cuu Long and Nam Con Son sedimentary basins, of high importance for the oil and gas industry, occur in its direct vicinity. This causes the expected results of further studies to have considerable significance for reconstructing the evolution of the South China Sea petroleum system.

Theme 9. Volcaniclastic deposits

Special Session 9.2. Impacts of volcanism on sedimentary systems

Oral presentation

Peperites in the Ukrainian Carpathian Mts – sedimentological perspective

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Peperites are special kind of very unique consortium of volcano-sedimentary rocks where sharp-boundaries volcanic pieces (usually basaltic) occur together with sedimentary deposits as result of episode of submarine eruption of basaltic lavas on the unconsolidated wet carbonate mud and were formed on the sea-floor during this eruption and disintegration of magma/lavas intruding and mingling with unconsolidated, or at least poorly consolidated, wet sediment and have to be automatically simultaneous with surrounding sediments. Usually peperites co-occur with another volcano-sedimentary rocks (basaltic pillow lavas, pyroclastic debris flows and volcanoclastic/pyroclastic turbidite system) which are perfect proof for age of volcanic activity by dating of limestones both by macro- and micro-fossils. In the Transcarpathian Ukraine peperites occur within the frontal part of the Marmarosh Massif, in the Pieniny Klippen Belt and in the western Chornohora Mts of the Outer Flysch Carpathians. The first one consists of the uppermost Jurassic/lowermost Cretaceous unit composed mainly by basic effusives represented by dark, thin-bedded limestones, black shales, sandstones and conglomerates with volcanic material and corse/fine-grained calcareous volcanoclastic/pyroclastic turbidites (flysch). In the Pieniny Klippen Belt the lowermost Cretaceous (Berriasian) carbonate succession occur, where its uppermost part is overlying by basaltic bed, synsedimentary limestone breccia with clasts of basaltic rocks and by peperites. By calpionellids the age of these carbonates are Middle Berriasian. Within Outer Carpathians some olistostrome complex occur and consists of olistolithes of various organogenic and organodetritic limestones with numerous fossils probably are Early Cretaceous age (Berriasian?) as well. This olistostrome complex has both extrusive (basaltic pillow lavas, melaphyre, etc.) olistolithes and volcanic-carbonate sedimentary breccias and also peperites. All mentioned facts indicate that volcano-sedimentary rocks, including peperites, in these tectonic units represent the same episode of submarine effusive activities within several parts of the Early Cretaceous Carpathian basins.

Theme 9. Volcaniclastic deposits

Special Session 9.2. Impacts of volcanism on sedimentary systems

Oral presentation

Investigation of the compositional spectrum of clay minerals within interbasaltic green volcaniclastic beds of Late Cretaceous Deccan volcanic province

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The present study integrates field, petrography, mineralogy and mineral chemical data to explain the origin of clay minerals associated with green volcaniclastic bed of Late Cretaceous Deccan volcanic province. A few cm to m thick, interbasaltic green horizon occur as isolated pockets and laminated beds. A petrographic study reveals that the green beds are altered tuffaceous rocks, mainly composed of altered basaltic grains (lathwork and microlitic texture), colourless to brown volcanic glasses (vitric texture) and plagioclase. Mafic minerals, opaques, quartz and apatite occur as minor constituents. Green clay dominantly occurs as a vein, vesicle and intergranular space fill and as replacing glasses and minerals. Brown clays, occasionally occur as replacing plagioclase and as void and vesicle fill. A detailed study of clay minerals is done using scanning electron microscope, XRD, visible and near-infrared spectroscopy (VNIR) and EPMA. Green clay shows lath-like microstructure, whereas brown clay shows flaky microstructure. XRD studies of <2 μm clay show prominent peaks at ~10 Å and 14 Å under air-dried conditions. The 10 Å peak remains unaffected, whereas the ~14 Å peaks shifts to ~17 Å on glycolation and collapse to 10 Å on heating. ~10 Å and 14 Å are coherent with celadonite and smectite, respectively. In VNIR study, the characteristic bands of almost equal strengths at ~2.30 μm and 2.35 μm and a strong slope between 1.00 μm and ~2.10 μm indicate celadonite. However, a doublet near 2.21 μm and ~2.25 μm and a band at 1.47 μm indicates the presence of smectite. The mineral chemistry of green clay shows a compositional range from Al-rich and K, Fe-poor member to Al-poor and K, Fe-rich member. The mineralogical and mineral chemical data demonstrates that the green clays range in composition from celadonite to ferroaluminoceladonite, whereas brown clay composition varies between Fe-montmorillonite and Nontronite. The diverse composition of clay ranging from K-poor smectite to K-rich celadonite indicates a fluctuation in the fluid condition (i.e., availability of cations and Eh–pH conditions) leading to change in the microenvironment of clay formation. Celadonite formation occurs in a slightly oxygen-depleted environment, i.e., dysoxic condition. However, smectite formation requires a more reduced fluid condition.

Theme 9. Volcaniclastic deposits

Special Session 9.2. Impacts of volcanism on sedimentary systems

Poster presentation

Pyroclastic deposits within Triassic limestones (Northern Italy): genesis, emplacement dynamics and diagenesis

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Volcanoes and carbonate factories are associated together in many marine realms. However, there is a lack of studies on the stratigraphy and minero-chemical properties of pyroclastic deposits within them. This work shows preliminary results of a multidisciplinary study conducted on pyroclastic deposits interbedded within a platform–intraplatform basin system in the Triassic Southalpine domain (Northern Italy). The platform environment has been also affected by ore-bearing fluids during its post-depositional history. Pyroclastic beds have been stratigraphically described, logged and collected in four different sites, three in the platform environment and one in the intrabasinal counterpart. Beds within the platform are 1 to 30 cm in thickness, beds within the basin are packaged in a more than 1 m-thick sequence. All are composed of ash particles, coarse in the basin, fine in the platform environment. Petrographic analyses reveal that pyroclastic material is largely composed of zoned plagioclase and quartz, minor putative oxidized amphiboles, and rare volcanic porphyritic lithics, revealing the intermediate composition of the magmatic source. Rare schist and gneissic lithics deriving from the Alpine basement are found as xenoliths. Texturally, the samples have been mainly emplaced by flows, although settling after floating into the water cannot be excluded for some layers. XRD analyses reveal that primary glassy groundmass wrapping pyroclastic particles have often been weathered into dolomite. This is mostly due to the circulation of hydrothermal fluids during the post-depositional history of the beds. SEM–EDS has been used to detect the presence of putative organic remains, biomineralization products, and the chemical composition of glassy groundmass remnants. In addition, sample locations have been included in a GIS database, and used to create 3D surfaces on which variations of chemical properties and mineralogical association have been modeled.

Theme 9. Volcaniclastic deposits

Special Session 9.2. Impacts of volcanism on sedimentary systems

Poster presentation

Controlling effect of tectonic movement in Chepaizi area on volcanic rock evolution and fracture distribution

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Located in the northwestern margin of the Junggar Basin in Xinjiang, China, the Chepaizi area features intense tectonic movement and evolving fractures. Previous research and determinations on the evolution of Carboniferous volcanic rocks and the stages of fracture development in this area remain controversial. This study systematically analyzes the formation framework, sedimentary and fracture characteristics, as well as the impact of tectonic movement in this area on the volcanic rock reservoir using the data of core, seismic, logging, oil and production test, especially various experimental data of rock mechanics. The results show that: (1) The volcanic rocks in this area have experienced the evolution process of "strong extrusion – weak extrusion – relatively weak extrusion – weak extension". The southeast represents eruptive facies, the west effusive facies, and the northeast volcanic sedimentary facies. Gray Tuff, basalt, andesite are dominant, and the sedimentary evolution sequence from old to new is semi-abyssal – abyssal – neritic – continental. (2) The Chepaizi area has experienced three development phases of structural fractures. In the middle and late Hercynian movement, it was squeezed and napped by NW-trending tectonic stress, thus developing the near-NS high-angle transverse fractures and the X-type conjugate shear fractures. During the Indo-China movement, it developed the near-NE expansion fractures under the action of compressive torsional-strike-slip stress. During the Himalayan movement, the NE and SW tensile stresses were dominant, resulting in the development of near-NW high-angle shear fractures. (3) Based on the comprehensive analysis of the above research results, the dominant reservoirs are divided into two types. Type I is mainly distributed in the east, south and northwest of the area, while type II mainly in the central area.

Theme 9. Volcaniclastic deposits

Special Session 9.2. Impacts of volcanism on sedimentary systems

Poster presentation

Trace-element budget of chlorite from hydrothermally altered volcano-sedimentary record of Adria passive margins

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This study offers new findings about how trace elements, and rare earth elements (REE) in particular, are distributed in various types of chlorite found abundantly in hydrothermally altered non-ophiolite effusive and tuffaceous rocks placed within the volcano-sedimentary Triassic record of Adria Microplate in the Dinaride region. By studying the geochemical signatures of chlorite formed under low-medium grade metamorphic conditions, including zeolite, prehnite–pumpellyite, and greenschist facies assemblages, this study has identified a diverse set of chlorite that exhibits unique REE signatures that can be categorized and defined by specific geochemical and textural parameters. The research shows that Fe-rich chlorite may have significant enrichments in REE, particularly in the LREE, compared to Mg-rich members. In addition, different textural varieties of chlorite, such as amygdales and pseudomorphic chlorite, have their own distinct trace element signatures. The study uses stable isotope geothermometric methods to determine the formation conditions of various chlorite samples, estimate the redox state using the enrichment/depletion of Ce and Eu, and make inferences about the sources of REE that provide the initial rare earth element budget of the fluids, all of which having brought further evidence on the dependence of REE chlorite abundances on the characteristics of hydrothermal fluids and chlorite geochemistry and mineralogy.

Theme 9. Volcaniclastic deposits

General Session

Oral presentation

Tuff from Nježić locality: $^{40}Ar/^{39}Ar$ age with integrated biostratigraphy

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Nježić is located in the eastern part of North Croatian Basin in Slavonia Region near the village of Nježić on the southwestern slopes of Papuk Mt. Within a 140-meter-thick sequence, five lithofacies have been distinguished: metagabbro facies, algal limestone facies, marl facies, bioclastic limestone facies and tuff facies. The metagabbro corresponds to the metagabbro of the Psunj metamorphic complex and represents Pannonian Basin System basement rocks. Algal limestones transgressively overlie the metagabbro, and are present only in the lower part of the sequence as a massive Lithothamnium limestone. About 70% of the deposits in the sequence are composed of marl which is most often massive and rich in microfossil fauna (planktonic and benthic foraminifera), as well as calcareous nanoplankton and fragments of bryozoans and echinoderms. Bioclastic limestones make up 5% of the sequence and appear as layers of centimeter–decimeter thicknesses through the entire sequence. About 25% of the sequence is occupied with the tuff facies. Thickness of the tuff layers ranges from >10 cm to almost 20 m. $^{40}Ar/^{39}Ar$ dating on the glass fragments from the oldest tuff layer in the sequence yielded a weighted mean age of 14.40 ± 0.03 Ma. All of the nannofossil assemblages, contain zonal marker species *Sphenolithus heteromorphus* Deflandre 1953 and are therefore attributed into NN5 Zone i.e. the middle part of the Badenian. Planktonic foraminiferal association contains representatives of genera *Trilobatus*, *Praeorbulina*, *Orbulina*, *Paraglobototalia* and *Globigerina*. Described planktonic foraminifera association with index species *O. suturalis* indicated middle Badenian age of sediments (planktonic foraminifera Zone M6). Benthic foraminifera assemblages indicate Lagenidae Zone with index species *Uvigerina macrocarinata* Papp & Turnovsky. Radioisotope dating result is confirmed by determined calcareous nannoplankton zone NN5 and the M6 Orbulina suturalis zone at the Nježić locality and according to chronostratigraphic similarity, tuff from Nježić locality can be correlated with Harsány ignimbrite in the Bükkalja Volcanic Field eruption unit.

Theme 9. Volcaniclastic deposits

General Session

Oral presentation

Depositional environment of the Late Ediacaran terrestrial volcanosedimentary succession in the Imiter mine area, north-eastern Saghro inlier, Anti-Atlas, Morocco

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New geologic mapping and lithofacies description from the volcano-sedimentary succession of the Eastern Anti-Atlas, constrain the late Ediacaran Ouarzazate Group (OG) evolution during the post-collisional stage of the Pan-African orogeny. Cores of total length up to 1.8 km intercepting the Imiter Mine Succession (IMS) in the northern Imiter mine area were logged and examined. The series of IMS comprises a thick pile of pyroclastic rocks and lava flows, sedimentary rocks, and is intruded by associated sills, granitoid plutons, and swarms of large dikes. We distinguished four mixed volcanic and sedimentary units (IMS I to IMS IV) that reflect a gradual change from fluvial to lacustrine depositional sedimentary environments. The lower episode, IMS I, starts with basal conglomerate generated by the erosion and disintegration of greywackes basement, and collected in topographic lows within the paleotopography. Minor intercalations of tuffaceous sandstone record the reworking of juvenile pyroclastics under mostly fluvial to alluvial conditions. The IMS II episode continues with variable amounts of tuffs and lapilli mass flows deposited under mainly lacustrine conditions. The occurrence of thick laminae and thin beds, as well as an abundance of slump structures, indicates significant deposition rates. Conglomerate sheets prograde towards the top of this unit, suggest a return to high-energy sedimentation. The IMS III episode is composed of pyroclastic fall deposits that contain a significant large proportion of volcanic blocks and bombs, and is restricted, in general, to very proximal settings. Reworked volcanic debris and intercalations of primary tuff may represent waning volcanism. During IMS IV episode, the volcanic activity started by thick rhyolitic ignimbrite and ended by voluminous eruptions. Localized slumping can be related to synsedimentary tectonic events. The conglomerates in the middle part of the formation imply an increased erosion rate with rounded clasts entering the depositional basin from farther afield. At the final stage, the fine-grained laminated tuff layers and the vertical columnar ignimbrites may be formed by cooling and contraction, in a lacustrine environment during the late Neoproterozoic.

Theme 9. Volcaniclastic deposits

General Session

Oral presentation

Tephrostratigraphy of the Early and Middle Miocene volcaniclastic horizons in Croatia-widespread silicic explosive eruptions

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The Neogene explosive volcanism of the Carpathian–Pannonian Region (CPR) is considered one of Europe's most productive in the last 20 Ma. Volcaniclastic horizons that can be linked to CPR silicic volcanism can also be found in various Croatian depositional basins. For properly defining volcaniclastic deposits, besides sedimentological features (which may be obscured due to poor outcrop conditions), petrological and mineralogical characteristics, high-precision geochronology and analysis of volcanic glass composition are required. In order to distinguish discrete eruption events and conduct tephrostratigraphic reconstructions, a detailed analysis of major and trace elemental composition of volcanic glass was conducted on Croatian Early and Middle Miocene volcaniclastic horizons, ranging from CPR ignimbrites to Dinaridic pyroclastic fall deposits. Volcanic glass major element composition was determined using an electron microprobe, accompanied by the determination of mineral assemblies, which enabled initial differentiation of individual Early and Middle Miocene volcanic events. In order to reliably pinpoint and distinguish separate volcanic products and eruptions that produced them, trace element composition of single glass shards obtained via laser ablation-inductively coupled plasma-mass spectrometry was used. The general pattern of trace element geochemistry of all analyzed samples can be related to CPR magmatic activity and shows a similar pattern of high LILE/HFSE, enrichment in Cs, Th, Pb and depletion in Nb, Sr and Eu. However, the differences between distinct eruptions can be identified using e.g., La/Nb-Th/Nb diagram and differences between HREE compositional trends. In conclusion, volcanic glass geochemistry proved to be a useful tephrostratigraphic tool for unaltered Miocene volcaniclastic marker horizons in the wider CPR area.

Theme 9. Volcaniclastic deposits

General Session

Poster presentation

Deposition of volcaniclastites in pelagic environment on rifted continental margin during the Middle Triassic

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The Middle Triassic volcano-sedimentary successions related to the opening of the Neotethys Ocean in NW Croatia were investigated for their age and facies interpretation. Stratigraphically stacked volcanic and volcaniclastic lithologies, ranging from basaltic to rhyolitic, are interlayered with pelagic sedimentary rocks in the studied sections. These successions were deposited on a passive continental margin with dynamics set by intense rift-related tectonic movements and volcanic activity. Following disintegration of stable shallow-marine environment newly formed lithospheric blocks gave rise to a complex pelagic depositional environment as extension progressed. Pelagic limestones and radiolarian cherts were deposited on drowned blocks with episodic intercalations of volcanic and pyroclastic deposits from the early Illyrian to possibly late Ladinian. Shallow-water carbonate environment still existed laterally as suggested by resedimented carbonate detritus. Deep-rooted normal faults created by extension provided paths for submarine basaltic extrusions. Magma quenched in contact with sea water creating basaltic hyaloclastites that were redeposited in deeper parts of the basin. Acidic volcaniclastics, commonly known as “pietra verde”, were produced by explosive volcanic eruptions, and deposited in pelagic environment by different gravitational mechanisms, including pyroclastic density currents. Variations in thickness of these deposits indicate different sedimentation mechanisms and reflect complex topography of the depositional environment. Water-settled air fall deposits produced thinner layers, while thicker layers indicate redeposition of material from topographic heights to more subsided parts. Unconsolidated pyroclastic detritus was partly reworked soon after deposition and redistributed gradually filing the basin. Medium- to fine-grade turbidite sedimentation is inferred for these deposits based on grain size, normal grading, horizontal lamination and mixing of volcanic and pelagic material. Presumed stratigraphic gaps in investigated successions, and possibly condensed sedimentation, can be explained by complex basin topography and prevailing sedimentation mechanisms, which resulted with sediment erosion and its subsequent redistribution.

Theme 9. Volcaniclastic deposits

General Session

Poster presentation

The oldest Miocene volcaniclastics of the Carpathian–Pannonian Region based on U–Pb zircon LA-ICP-MS dating in the Mura Depression (Northwestern Croatia)

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Volcaniclastic rocks are important markers in the stratigraphic correlation of deposits and interpretation of the evolution of sedimentary basins, especially when there are no reliable biostratigraphic data. These rocks have been drilled in more than 20 exploration wells in the Mura Depression (Hrvatsko Zagorje Basin) in Northwestern Croatia (SW part of the Pannonian Basin System). They cover more than 235 km^2 of the exploration area and are of considerable thicknesses (>1500 m in successions in some wells). Several methods have been used to reveal characteristics of the rocks: petrographic analyses with macroscopic and microscopic (thin section) examinations using polarizing light microscopes, geochemical analyses of major and trace elements using ICP-MS and ICP-ES, geochronological analyses using U–Pb LA-ICP-MS on zircons, as well as rocks' comparison and correlation using 2D and 3D seismic and well-log data. Volcaniclastic rocks are mostly crystaloclastic, lithoclastic, and vitroclastic tuffs, lapilli tuffs, and lapillistones, subordinately pyroclastic and tuff breccias, and tuffites. To a lesser extent, extrusive rocks are also present. The rocks are mainly classified as dacite, andesite, and, to a lesser degree, rhyolite, and belong to calc-alkaline and high-K calc-alkaline series. They are characterized by the enrichment of incompatible trace elements compared to compatible ones, with the ubiquitous negative Nb–Ta anomaly. Geochronological analyses yielded ages of eruptions and depositions of the volcanic material in the range of 23.45–20.98 Ma (23.19±0.26 to 21.23±0.25 Ma). The study covered large volumes of volcaniclastics which indicate significant and strong volcanic activities at the transition from the Paleogene (Oligocene – Chattian) to the Neogene (early Miocene – Aquitanian). Large thicknesses of the rocks indicate volcanic eruptions that continued during the Aquitanian, i.e., Egerian and Eggenburgian stages according to the Central Paratethys stratigraphic division. These rocks are the oldest volcaniclastics of the Miocene epoch in this part of Croatia and in the wider area of the Pannonian Basin System. It remains an open question whether they reflect volcanism related to the Periadriatic lineament of the Alps or one related to the initial opening of the Pannonian Basin System.

Theme 9. Volcaniclastic deposits

General Session

Poster presentation

Volcanic ash layers in Mid-Carnian turnover siliciclastics of the East Bosnian Durmitor Megaunit in the northern Montenegro

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The demise of the Wetterstein Carbonate Platform (WCP) evolution s. str. (latest Ladinian to earliest Julian) in the Western Tethys Realm is discussed controversially. In the ALCAPA region of the Western Tethys Realm and the Southern Alps the WCP shows a drowning related to the Lunz event (Reingraben event, Mid-Carnian Pluvial Episode or Mid-Carnian Wet Intermezzo). However, prior to the drowning of the WCP with siliciclastics the platform emerged due to a sea-level drop, and the underfilled accommodation space between the platform areals became restricted deep lagoonal areas with deposition of in parts organic-rich siliceous limestones (carnica event), followed by the deposition of fine-grained siliciclastics (Reingraben claystone). Whereas in the northwestern part of the Western Tethys Realm including the Outer Dinarides in Croatia, these siliciclastics were widespread deposited, they are practically unknown in the Inner Dinarides to Hellenides. In contrast to the ALCAPA region in the Dinarides/Hellenides a long-lasting stratigraphic gap is common. Carbonate deposition started again earliest in the Late Carnian after the demise and uplift of the WCP in the Julian. In the East Bosnian Durmitor megaunit in northern Montenegro, near the village Pliješevina, the final demise of the WCP lies in the Julian carnica conodont biozone, dated by *B. diebeli*, *Gl. malayensis*, *Gl. tethydis* and *Gladigondolella*-ME, *M. carnica*, *Neocavitella* sp. juv., *Pg. foliata*, *Pg. polygnathiformis*, *Ps. murcianus*, and *Pg. tadpole*. Above the resediments of the WCP grey filament- and radiolarian-rich biomicrites deposited, followed upsection by siliceous claystones, black cherts and silicified volcanic ashes. The carbonate-free metabentonites of the Mid-Carnian are composed of (biogenic) quartz, montmorillonite, mica-group (mainly illite), smectite group, and mixed layer clay minerals (e.g. rectorite). In addition, some layers contain also kaolinite and goethite, which indicate (sub)tropical weathering in the hinterland, where bauxites were formed. This roughly 6 m thick series is overlain by medium grey filament bearing biomicrites with *M.* cf. *precommunisti*, *N. cavitata*, *Pg. nodosa*, and *Pg. polygnathiformis*. These results clearly evidence volcanic activity younger as the carnica event, i.e. higher Julian to Tuvalian.

Theme 10. Evaporites

Special Session 10.1. Evaporitic sedimentary environments, processes and products, with emphasis on the Messinian Salinity Crisis

Keynote lecture

Palaeogeographic evolution of the Betic Seaway closure (Betic Cordillera, Spain)

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During the Late Miocene, the Betic Seaway in south Iberia was one of the main connections between the Mediterranean and the Atlantic, together with the Riffian Seaway in north Morocco. The closure of the Betic Seaway during the late Tortonian due to the Iberia–Africa plate convergence had relevant consequences in the Mediterranean, as it was one of the main triggers of the Messinian Salinity Crisis (MSC). That closure was progressive and took place along the Tortonian and early Messinian, causing the continentalization of the marine basins associated with the seaway (inner Betic basins) which developed important evaporite deposits. Here we study the transitional and continental records of some of these Betic basins that are key to reconstructing the palaeogeographic and chronologic evolution of the Betic Seaway: the Las Minas, Campo Coy, Guadix and Granada basins. Using palaeomagnetic, palaeontological and geochemical (sulphur and Sr isotopes in evaporites) proxies, we establish that the western Las Minas and Campo Coy basins were continentalized during the early–middle Tortonian, although the marine influence in the Las Minas Basin lasted until the Late Tortonian marked by cyclic seawater incursions. On the contrary, no marine influence existed in the Campo Coy Basin after its continentalization, and its continental record comprises from the middle Tortonian to the Pliocene including the MSC. The Guadix and Granada basins, located to the west, were marine until the late Tortonian around 7.2 and 7.5 Ma. The transitional record of the Guadix Basin is continuous and does not show any sedimentary hiatus as previously proposed, so we can assume that the Almanzora corridor was closed during the Late Tortonian. The Granada Basin was configured as a highly restricted marine basin only connected to the Mediterranean during its transition, giving rise to thick halite deposits showing seasonal cyclicity similar to the Dead Sea case. In short, the Betic Seaway was progressively closed westward along the Tortonian and most of it was closed after the Guadix continentalization at 7.5 Ma, leaving as a unique potential Atlantic–Mediterranean connection the Guadalhorce corridor and the Palaeogibraltar Strait to the west.

Theme 10. Evaporites

Special Session 10.1. Evaporitic sedimentary environments, processes and products, with emphasis on the Messinian Salinity Crisis

Oral presentation

The Indalecio section, a new Messinian salinity record in the Tabernas Basin (SE Spain)

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Here we present a new Messinian Salinity Crisis (MSC) section at Rambla de Indalecio, (Tabernas basin, SE Spain). The section is >200 m thick and includes pre-evaporitic, evaporitic and post-evaporitic deposits. We apply magnetostratigraphy and biostratigraphy to constrain the age of this stratigraphic succession; we also analyse the sulphur and oxygen isotopic compositions in the gypsum together with the $^{87}Sr/^{86}Sr$ ratios to characterize the origin of the brines. The Indalecio section can be divided into seven units: a) >100 m of turbiditic deposits losing upwards its fossil content, b) a >3 m bed with resedimented gypsum lying on top of an erosional surface. c) 30 m of stratified massive selenitic gypsum beds, including a second bed with re-sedimented gypsum. d) 15 m of selenitic gypsum that alternated with resedimented gypsum, separated by erosional surfaces. e) 20 m of resedimented gypsum and marls with evidence of gravity instabilities f) 5 m green/grey marls rich in ostracods and bivalves associated with Lago Mare facies. g) A regional erosive surface overlaid by fan delta deposits assigned to the Pliocene Abrioja Fm. Palaeontological and palaeomagnetic information constrains the age of the pre-evaporitic deposits and shows evidence of early Pliocene deposits above the gypsum. Gypsum geochemistry characterizes the studied gypsum succession as MSC Lower Gypsum (LG). Foraminiferal assemblages allow estimating the water depths for the lower turbiditic deposits to occur in a deep marine zone (bathyal) while the overlaying gypsum selenitic platforms are considered not to form below depths of 200 m. The presence of resedimented gypsum beds containing clast of corals and carbonates, derived from marginal areas, above the turbiditic deposits, suggests an important sea-level drawdown in the Tabernas basin during the Primary LG. This sea-level fall occurred during the sedimentation of the LG and could be expressed in shallower basins, like Sorbas, as the change in evaporitic facies (massive to branched) that occurs after cycle five and is documented around the Mediterranean. However, the active tectonic activity during the MSC in this region should be carefully considered, evaluating the relative impact of the Mediterranean restriction vs local tectonic uplift of this drawdown.

Theme 10. Evaporites

Special Session 10.1. Evaporitic sedimentary environments, processes and products, with emphasis on the Messinian Salinity Crisis

Oral presentation

The sedimentary record of the Yeson Alto and Rambla de Lanujar sections (Tabernas Basin, SE Spain): implications for the Messinian salinity crisis

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Despite being known for its remarkable Tortonian turbidites, the Tabernas Basin (SE Spain) also exhibits an outstanding depositional record of Messinian age, containing valuable information on the evolution of the Messinian Salinity Crisis (MSC). This work presents new stratigraphic and palaeoenvironmental data of Messinian successions of the Tabernas Basin. Two sections were selected: Rambla de Lanujar (RL) and Yesón Alto (YA). Both were systematically logged, mapped and sampled for sedimentological, petrographical, geochemical and paleontological characterization. A proposal of their correlation with the nearby MSC sedimentary record of the adjacent Sorbas basin is also presented. In the RL section, a pre-evaporitic unit (30 m) of fine-grained mixed-siliciclastic deposits containing benthic foraminifera fauna is conformably overlain by beds of nodular gypsum and few primary selenite gypsum forming radial structures (flat selenitic cones) up to 2.5 m in diameter. A preliminary analysis of the pre-evaporitic deposits reveals an upward decrease in the benthic foraminifera content, associated with the absence of planktonic fauna. The YA section is a larger outcrop, located away from the basin margins, and records a >80 m-thick unit of fine-grained siliciclastic deposits, cut by a wide and continuous erosional surface. Lying above it, a 8 m-thick unit of resedimented clasts, including large blocks of gypsum deposited, is found. Above this unit, at least four cycles of gypsum beds appear intercalated with fine-grained deposits. These evaporites are mainly represented by continuous beds of vertically-oriented, massive selenite crystals. A level with abundant bivalve bioclasts was observed in one of the inter-evaporitic intervals, implying that normal marine conditions prevailed in the basin when evaporitic deposition ceased. The observed erosional surface at YA and associated resedimented gypsum may indicate that the first selenitic gypsum bed deposited in the central part of Tabernas basin does not correspond to the initiation of the gypsum sedimentation in the marginal areas. In-progress geochemistry analysis of Sr, S and SO_4 isotopes will determine if these evaporites were deposited in an advanced stage during the deposition of the Primary Lower Gypsum, or correspond to the Upper Gypsum unit.

Theme 10. Evaporites

Special Session 10.1. Evaporitic sedimentary environments, processes and products, with emphasis on the Messinian Salinity Crisis

Oral presentation

The classical Messinian Rio Aguas section revisited (Sorbas Basin, Spain)

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In this work, the Rio Aguas (RA) Messinian section, which is well known by its impressive examples of gypsum supercones, was revisited with the objective of produce a stratigraphic/petrological characterization. First, we created a 3D photogrammetric model of the RA section using a drone equipped with a 24 MP resolution photographic camera. 600 pictures were treated with the software Agisoft Metashape. Second, we drew the different lithostratigraphic units on the 3D model. Third, we measured the complete RA section distinguishing four lithostratigraphic units that were sampled. Finally, we analyzed the sedimentary rocks of this section from a petrological, mineralogical, geochemical, and micropaleontological perspective, with special emphasis on the laminated marls that crop out between selenite gypsum beds. According to these results, the vertical evolution for the Messinian Salinity Crisis sedimentary setting was assessed. The 3D model allows a detailed identification of the different stratigraphic units and a great definition of the basal gypsum supercones, allowing different interpretations. The four lithostratigraphic units defined are: 1) A basal gypsum–marl sequence with three cycles with the uppermost cycle showing discontinuous gypsum bodies; 2) a marly/carbonate unit affected by gravitational instabilities (slumps); 3) a marly/lutitic unit with manganese layer on top; and 4) a laminated carbonates unit overlined by a sandy carbonate. The petrological/mineralogical characterization allows distinguishing different sedimentary facies from fine grained laminated to massive carbonate-rich to sand-rich deposits. No microfossils have been identified in the RA section to date, although there is work in progress in that regard. As a whole, this succession can be interpreted as a shallowing upward sequence. The origin of the gypsum supercones in the RA section is also discussed, and two hypotheses are evaluated based on our observations: (i) synchronous gypsum/marl sedimentation vs (ii) a diachronous development of these bodies, with initial nucleation of gypsum cones inside the marls followed by rapid vertical development of the cones forming positive topography and posterior infilling of the intercone space.

Theme 10. Evaporites

Special Session 10.1. Evaporitic sedimentary environments, processes and products, with emphasis on the Messinian Salinity Crisis

Oral presentation

Resedimented where? Messinian hemipelagic deposits interbedded with clastic gypsum facies from the Belice Basin (Italy)

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The reconstruction of the depositional modes of ancient evaporitic basins relies on the comparison with modern coastal and shallow water hypersaline environments (artificial salt works, lagoons, and sabkhas). However, there are several examples of deep-water evaporitic basins in the geological past, but their interpretation is challenged by the absence of modern analogues. In these basins, clastic evaporites, emplaced by various types of gravity flows, are common and usually interbedded with fine-grained “hemipelagic” sediments, representing the original signal of the host basin, and laminated evaporite deposits resulting from the settling of crystals nucleated in the water column (cumulite deposits). A prominent example is the Resedimented Lower Gypsum (RLG) unit that was deposited, along with halite, in the deep Mediterranean basins during the acme of the Messinian salinity crisis (MSC, 5.60–5.55 Ma). Much attention was given in the past to the clastic gypsum facies of this unit, formed at the expense of a marginal evaporitic platform. In contrast, the interbedded “hemipelagic” and cumulite deposits were generally overlooked, although their study can provide crucial information on the chemical, physical and biological conditions in the water column and at the seafloor. This work focuses on the RLG unit exposed in the Belice Basin (NW Sicily, Italy). Here, gypsum turbidites and mass transport deposits are interbedded with finely laminated gypsiferous and diatomaceous sediments that are typified by open marine diatom assemblages. Preliminary sedimentological and petrographical results indicate that clastic gypsum was emplaced in a (relatively) deep basin, characterized by normal marine conditions in the upper water column and, at least intermittently, by high biosiliceous productivity. These results challenge the idea of a severe sea level drop and a sharp rise of salinity in the whole Mediterranean Basin, during the acme of the MSC.

Theme 10. Evaporites

Special Session 10.1. Evaporitic sedimentary environments, processes and products, with emphasis on the Messinian Salinity Crisis

Oral presentation

Unravelling a puzzling gypsum lithofacies: the Messinian branching selenite

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The onshore evaporitic record of the late Miocene Mediterranean Salt Giant retains a wide array of gypsum lithofacies whose environmental interpretation is still largely debated because of the lack of modern analogues. Among them, selenites, i.e. gypsum crystals larger than 2 mm, are the main constituent of the Mediterranean gypsum deposits. These crystals compose the massive, banded and branching selenite lithofacies. Massive and branded selenite, also described from other ancient evaporite deposits, represent bottom-grown precipitates from calcium and sulfate saturated brines. The branching selenite is a still enigmatic, peculiar lithofacies of many Mediterranean subbasins (e.g. Sicily, Piedmont and Vena del Gesso basins in Italy and Sorbas and Nijar basins in Spain). It formed during the first phase of the Messinian salinity crisis (5.97–5.60 Ma) and appeared simultaneously in the stratigraphic record from about 5.87 Ma. Such lithofacies is commonly associated with fine grained, laminar gypsum (cumulite) deposits. In this work we use novel sedimentological, petrographic and geochemical data to investigate the origin of the branching gypsum lithofacies from different Mediterranean localities. So far both a diagenetic and a primary bottom-grown interpretation have been attributed to this puzzling lithofacies. The studied crystals entrap relicts of cumulitic gypsum and are surrounded by dolomitic mudstone; such observations are in favor of a syngenetic growth of the branching crystals under reducing conditions, close to the sediment–water interface, at the expenses of dissolved cumulitic gypsum following intense bacterial sulfate reduction. The simultaneous appearance of the branching selenite lithofacies and cumulite deposits suggests a further restriction of the Mediterranean basin and the intensification of water column stratification.

Theme 10. Evaporites

Special Session 10.1. Evaporitic sedimentary environments, processes and products, with emphasis on the Messinian Salinity Crisis

Oral presentation

Leaving (almost) no trace: diagenetic alteration of biosiliceous sediments during the Messinian salinity crisis

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Deciphering the diagenetic processes affecting marine biogenic sediments is of utmost importance for paleoenvironmental reconstructions. This is especially true for sediments deposited in the course of dramatic paleoceanographic turnovers that might have negatively impacted marine biota. The upper Miocene sedimentary record of the Mediterranean offers the opportunity to investigate this issue. Between 5.97 and 5.33 Ma, during the Messinian salinity crisis (MSC), the Mediterranean was turned into the youngest salt giant of Earth history. Paucity or total absence of biomineralized remains in the MSC sediments was attributed to hypersaline conditions in the water column, that triggered the annihilation of marine life. In this research, we explore the possibility that the absence of biogenic remains reflects diagenetic alterations of the sediments. We studied two sections from NW Italy typified by dolomitic and diatomaceous sediments interbedded with primary gypsum beds. The non-evaporitic components were investigated throughout a combination of sedimentological, petrographic, elemental, mineralogical, and geochemical analyses. We observed different contents and degrees of preservation of biogenic silica, from abundant and excellently preserved (diatomaceous shales) to rare and severely altered (dolomitic mudstones). Such variability reflects the remineralization pathways of organic matter associated with biogenic silica, depending on bottom and pore water redox conditions governed by the water column structure. Oxic conditions induced by water column mixing favored biogenic silica preservation, while bottom water anoxia during prolonged water column stratification promoted dolomite precipitation, dissolution of biogenic silica and extensive neoformation of clay minerals. These results challenge the hypothesis of a complete annihilation of marine biota during the MSC.

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Special Session 10.1. Evaporitic sedimentary environments, processes and products, with emphasis on the Messinian Salinity Crisis

Oral presentation

The Sofia 7 core: new insights into the Messinian sedimentary record of the Sorbas Basin

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The Sorbas basin (SE Spain) has been the subject of numerous studies because it exposes the most complete sedimentary record of the Messinian Salinity Crisis (MSC) in the Western Mediterranean. The Sorbas sedimentary succession exposes >50 pre-evaporitic sedimentary cycles (Abad Mb) covered by up to 16 evaporitic cycles of the Yesares Mb and by up to three-to-four lagoon/beach cycles of the Sorbas Mb. The most recent MSC deposits are represented by the reddish continental deposits of the Zorreras Mb which includes two white carbonate lagoonal units and is covered by shallow-marine Pliocene deposits. This general stratigraphic architecture was built by integrating partial sections from the basin, due to the lack of a continuous outcrop including all these four MSC units. This study presents, for the first time, a complete record of the MSC units in the Sorbas Basin, based on the study of the Sofia 7 core, drilled by the company Saint-Gobain Placo Ibérica. The core (up to 174.5 m deep) records from bottom to top the Abad (8 m), Yesares (124.5 m), Sorbas (34 m) and Zorreras (9 m) units with >90% recovery. It is remarkable that the core cuts four thick evaporite cycles formed by selenitic and nodular gypsum interbedded with inter-evaporitic levels of massive and laminated marls that compose the Yesares Mb and marls with sapropelic levels of the pre-evaporitic Abad Mb of the Turre Fm. The petrographic characterization of the carbonates, marls and gypsum beds has been carried out by optical and scanning electron (SEM/EDS) microscopy. The mineralogical and elemental composition of the core rocks has been determined by X-Ray Diffraction (XRD) and with a portable X-Ray Fluorescence (XRF) instrument (Bruker Tracer 5G handheld spectrometer). The sulphate isotopic composition of evaporite samples has been determined, while discrete measurements of the radiogenic Sr isotopes have been collected within the different units of the core. Finally, within the marls from Abad Mb and in the inter-evaporitic levels, samples have been taken for micropaleontological analysis and total organic matter content (TOC). The study of this core allows a detailed petrological/mineralogical/geochemical and micropaleontological characterization of the different MSC units in a specific location of the Sorbas Basin.

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Special Session 10.1. Evaporitic sedimentary environments, processes and products, with emphasis on the Messinian Salinity Crisis

Poster presentation

The evaporites of Zakynthos Island (Ionian Sea, Greece): new insights for the Messinian Salinity Crisis in the Eastern Mediterranean

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The Messinian Salinity Crisis (MSC) represents the last Salt Giant event on Earth with deposition of a great volume of evaporites across the Mediterranean. Over the years, two main litho- and chrono-stratigraphic frameworks have been proposed for the deposition of the MSC evaporites: 1) the classical MSC "two-step" model with the stratigraphic division into Lower Gypsum and Upper Gypsum, and 2) the MSC "three-stage" model with Primary Lower Gypsum-MSC stage 1, Resedimented Lower Gypsum-MSC stage 2, and Upper Gypsum-MSC stage 3 units.

In Zakynthos Island (Ionian Sea, NW Greece), the MSC evaporites crops out in the southern coast and central part of the island consisting of "in-situ" vertically oriented selenites, fine grained laminated gypsum and clastic gypsum deposits, including selenite blocks, gypsarenites and gypsirudites. These MSC evaporites have been studied in four (Agios Sostis, Panagia, Kalamaki, and Argassi) sections. The Agios Sostis and Panagia sections consist of clastic gypsum deposits derived from the erosion and resedimentation of selenite platforms previously formed on shallower surrounding areas. The Kalamaki and Argassi sections mostly consist of "in-situ" vertically oriented selenites and fine grained laminated gypsum deposits alternating with gypsarenites and gypsirudites intervals.

Preliminary sulfate isotope compositions from Agios Sostis and Kalamaki gypsum are very homogeneous with values of $\delta^{34}S$ ~23‰ (21.0–26‰) and of $\delta^{18}O$ ~13‰ (12–15‰) respectively, falling within range with those reported for the MSC Lower Evaporites.

Despite the current acceptance of the MSC "three-stage" model applied to different MSC evaporites in the entire Mediterranean, the presence of "in situ"' vertically oriented selenites interbedded with clastic gypsum deposits entail coeval deposition, involving erosion and redeposition possibly during the same evolutionary stage. These gypsum facies distributions show some discrepancies with the application of the 'three-stage' stratigraphic subdivision to Zakynthos MSC evaporites and open the possibility to be considered as MSC Lower Evaporites in the classical MSC "two-step" model. However, future related work is needed to finally consider such evaporitic facies as representative of the classical MSC "two-step" or the "three-stage" model.

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Poster presentation

Permian–Triassic sedimentary and diagenetic reconstruction of the southern Adriatic area

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Three cores coming from the Permian–Triassic interval of the Puglia 1 well were studied. Core 1 (5.048–5.056 m – Triassic) is characterized by laminated dolomudstones with thinly microbial laminae alternated to lenticular/tabular shaped anhydrite crystal levels, suggesting an intertidal/sabkha-type environment. Core 2 (6.067–6.075 m – Triassic), shows coarse-grained crystalline massive dolomite with remnants of oolites and shell fragments, defining a marginal shallow-water setting. Core 3 (6.372–6.379 m – Permian) includes quartzolithic sandstone with iron oxides, clay (illite, kaolinite+chlorite) and dolomite, ankerite, calcite cements, indicating a continental setting. Dolomitization is ubiquitous and occurred early after the deposition through the circulation of high saline dolomitizing fluids under reducing conditions. The early-dolomitization preserved the dolomites from major burial diagenetic transformations, permitting only the ordering and the development of xenotopic textures in the dolomite crystals (aging). Primary anhydrite crystals were lately affected at least by one burial hydration–dehydration cycle, whereas fracture-filling anhydrite is a later-stage diagenetic product of circulating sulphate-rich fluids. The integration of other six wells and a seismic line allowed the reconstruction of the Permian–Triassic sedimentary evolution of the Southern Adriatic area. During Permian continental/coastal lagoon settings developed, while in the Ladinian, after a generalized subaerial exposure and an erosional phase, the extensional tectonic inputs linked to Tethys rifting brought to a relative sea-level rise and to the formation of carbonate shelves in NW–SE oriented tectonic depressions. During Carnian–early Norian a further extensional tectonic pulse coupled with a relative sea-level drop, led to the formation of NW–SE elongated intrashelf basin with a consequent enhancement of salinity and settlement of evaporative conditions. This triggered a massive evaporite deposition during the Norian, that filled the intrashelf basinal areas. Lastly, in the late Norian–Rhaetian a marked relative sea-level rise, restored the connections with open-sea and shifted the evaporite deposition up to the shallowest parts that previously remained under subaerial conditions.

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Poster presentation

Authigenic clays and evaporites from the Makgadikgadi salt pans (Botswana): from Quaternary paleoenvironments to astrobiology perspectives

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The Makgadikgadi Basin in Botswana developed from the Late Pleistocene onwards due to gradual shrinking of the giant Lake Palaeo-Makgadikgadi (LPM). This basin, in the central Kalahari, is now covered by one of the largest salt flats in the planet. Ostracod assemblages are dominated by the *Limnocythere* ssp., an opportunistic taxa colonizing the littoral areas of shallow evaporative, ephemeral lakes. The sediments from the pans show fluctuations in the Cl/K and Ca/Cl ratios, often in phase with the relative abundance of *Limnocythere* suggesting a cyclicity induced by changes of salinity and alkalinity in the water. Recent multi-proxy study documents the occurrence of a Late Pleistocene shallow, playa lake environment typified by strongly alkaline waters. Between ca. 16 and 2 ka BP, a prolonged drought with sustained aeolian conditions affected the study area. A subsequent, short humid period is followed by an overall desiccation trend that likely started with the Little Ice Age and continues until the present day. XRD and Raman analyses revealed the presence clastic quartz and evaporite minerals such as halite and gypsum and ubiquitous calcite both clastic, biogenic and authigenic in origin, from surface and shallow cores sediments. Raman analysis revealed the presence of unidentified clay minerals. Hence, some of the samples from the Makgadikgadi Salt Pans were processed for the preparation of oriented sections for clay minerals identification. Clay minerals identified were: illite, smectite, mixed-layer clays (probably chlorite), and kaolinite. No consistent clay mineralogical variation with depth was found. The authigenic clays present formed in the pans during periods of increased water alkalinity, high dissolved magnesium contents and relatively low detrital input, probably during dry winter periods. On the other end, detrital clay materials were brought in by the ephemeral rivers during the wet summer months. The identification of clay minerals in the Makgadikgadi Salt Pans has important implications for astrobiological studies as clays have been described by robotic mission on Mars in evaporitic environments similar to those described here. The clay mineral deposits on Mars are a primary target for astrobiological and habitability studies.

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Poster presentation

Sedimentary history of the Salar de Uyuni (Bolivia) from a 460 m drill core

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Located south of the Bolivian Altiplano at 3650 m asl the Salar de Uyuni is the largest (10,262 km^2) salt flat in the world. Lacustrine carbonate rocks representing the record of higher water levels in the basin appear around the Salar and on islands within the lake. However, these exposures are very limited and do not allow a complete study of the sedimentary filling. Drill cores is the only means to access to the sedimentary record that underlies the salt pan. In this regard, two scientific cores have been drilled, reaching depths of 121 m by ORSTOM in 1989, and second of 220 m by Duke University in 1999. This contribution presents the analysis of a new core drilled in 2015 by Yacimientos del Lítio Bolivianos state company (YLB) at a depth of 460 m, thanks to a research agreement between YLB and the University of Barcelona. In contrast to these previous drill cores that were located close the geographic centre of the Salar, the new core was drilled in the eastern part of the Salar, around 14 km from the margin of the salt flat. This location was chosen based on available geophysical data in order to target a depocenter of the Salar. Petrological and mineralogical results permitted to characterize the following lithofacies: massive halite, banded halite, interstitial halite, gypsum, marls and carbonates, volcanic ash, clays and red silts. These lithofacies have been interpreted to represent a succession of sedimentary environments varying from mud flat, salt pan, perennial shallow saline lake to perennial freshwater lake environments. The chronology of the core was established based on $^{39}Ar/^{40}Ar$ dating of sanidine phenocrysts in seven tuffs intercalated in the section, and magnetostratigraphy. The results demonstrate a long and discontinuous sedimentary history from the middle Pliocene to the late Pleistocene. The tuff layers have also been geochemically characterized, and one of them correlated to the cores drilled by YLB in the Salar and with previously published cores showing important lateral variations in the Salar facies. The study of this new core highlights the unusual complexity in the facies architecture and spectacular variations in sedimentation rates, especially during halite deposition. In addition, we relate the sedimentary record to past climate and salt-mediated tectonic processes in this region.

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Special Session 10.1. Evaporitic sedimentary environments, processes and products, with emphasis on the Messinian Salinity Crisis

Poster presentation

Geochemical evidence of Messinian Salinity Crisis in the Adana Basin, southern Turkey

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The Messinian Salinity Crisis which occurred at the end of the late Miocene, and gave rise to salt precipitation in the deep basins while gypsum precipitation in the marginal basins of the Mediterranean. The Adana Basin located in most northeastern part of the Mediterranean and gypsum deposits outcropped in the basin are evidence of that it is a marginal basin. In the basin, three different facies associations were recognized which were precipitated/deposited in the mud-flat/sabkha, shallow-water, and deep-water environments. We carried out strontium, sulphur, oxygen isotope analyses and elemental analyses on 32 samples of gypsum facies that were precipitated/deposited in those different depositional environments. Strontium, sulfur, oxygen isotope analyses are used to recognize whether the evaporite precipitation/deposition occurred in the marine water body, nonmarine water body or hybrid water body, and dating the time interval of precipitation/deposition. $^{87/86}$Sr isotope values of 31 samples ranging from 0.708845 to 0.70919 and within the range of global Late Miocene marine sediments. Therefore, these values correspond to Sr isotope values of Primary Lower Gypsum that precipitated/deposited during Messinian and does not indicate isotopic values of Upper Gypsum unit. The δ^{34}S values ranging from 23.2 to 25.5‰; δ^{18}O SO_4 values 11.7–16.2‰ are higher than isotope values late Neogene seawater. This may have been explained as a result of redox processes of bacterial sulfate reduction. Only one gypsum-bearing sandstone sample has distinct δ^{34}S and δ^{18}O SO_4 values, 0.708787‰ and 9.1‰ respectively. This may have been interpreted as evidence of continental contribution that affected the depositional evnironment during deposition of the sample.

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Special Session 10.1. Evaporitic sedimentary environments, processes and products, with emphasis on the Messinian Salinity Crisis

Poster presentation

Using isotopy of Ca-sulfates for documenting marine-to-nonmarine transitions in Neogene basins (Betic Cordillera)

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Subsequently to the structuration of the Betic Cordillera (Early–Middle Miocene), important evaporite sedimentation occurred during the late Tortonian–early Messinian time interval in the Betic intermontane basins (Granada, Lorca, Fortuna, Campo Coy, Hellín, Jumilla, Baza). Depending on the basins, one or several evaporite formations are recorded (mainly Ca-sulfates and chlorides), which are associated with pre-evaporitic deposits such as marls, carbonates, diatomites, paper-shales, oil-shales, and early diagenetic mineralizations (native sulphur and celestite replacements). Sedimentation in these basins evolved from marine to lacustrine settings, but this evolution is not always clearly reflected in the evaporite lithofacies. The use of geochemical markers, mainly stable isotopy ($\delta^{34}S$, $\delta^{18}O$) of gypsum–anhydrite rocks, has allowed documenting the hydrologic–paleogeographic changes in the various stratigraphic successions, and the general chemical recycling of Triassic sulfates into the late Tortonian–early Messinian evaporites. In the early stages of restriction, the $\delta^{34}S$ values of sulfates paragenetic with the salt show similar evolutions as do the elemental markers (mainly bromine) in halite crystals, which indicate progressive supplies of non-marine waters to the initial marine brines. Afterwards, the predominance of gypsum–anhydrite formations in the stratigraphic successions indicates progressive brine dilution. Together with the general dilution, the change from marine to lacustrine settings is substantiated by the following decrease in $\delta^{34}S$ values in the Ca-sulfates: from ~20–22‰ (marine waters of the Late Miocene) to ~17–18‰ (mixing of marine waters with non-marine waters bearing dissolved Triassic sulfates) and to ~15–16‰ (non-marine waters with dissolved sulfate coming from the most abundant Triassic evaporites in the country rocks, i.e. Keuper gypsum–anhydrite, indicating lacustrine settings without significant marine supplies).

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Special Session 10.1. Evaporitic sedimentary environments, processes and products, with emphasis on the Messinian Salinity Crisis

Poster presentation

Geological map of a Messinian deep water evaporitic basin (Belice Basin, NW Sicily, Italy)

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The youngest Salt Giant on our planet was formed during the Messinian salinity crisis (MSC) (5.97–5.33 Ma), a major paleoceanographic event that strongly impacted marine biota and the paleogeographic setting of the Mediterranean basin. The MSC succession is representative of both shallow-water and deep-water basins. While the interpretation of shallow basins is facilitated by comparison with evaporitic rocks forming in modern coastal and shallow hypersaline environments, the reconstruction of deep basins is problematic, mostly because of the absence of modern analogs. Stratigraphical and sedimentological models of different deep evaporitic basins worldwide have shown that clastic evaporitic bodied emplaced by various types of gravity flows are interbedded with "hemipelagic" sediments that reflect the original environment of the basins. One example is the Resedimented Lower Gypsum unit (RLG) that was deposited in different deep Mediterranean basins during the acme phase of the MSC and is exceptionally exposed in the Belice Basin (NW Sicily, Italy). We present here a detailed geological map of the Belice Basin at the scale of 1:10.000, which has allowed us to reconstruct the stratigraphic architecture of the RLG unit. This unit overlies, through an erosional surface, on upper Tortonian and lower Messinian siliciclastic sediments (Terravecchia Unit) and is followed by the Messinian Lago-Mare sediments or Lower Pliocene open marine deposits (Trubi Unit). The RLG unit can be subdivided into two informal subunits separated by an erosional unconformity. The lower subunits consist of well-bedded gypsum turbidites alternated with diatomaceous mudstones and laminar cumulitic gypsum deposits. The upper subunit is a mass transport deposit, consisting of mountain-sized gypsum blocks embedded in a slumped fine-grained matrix, recording impressive mass wasting events at the expense of a marginal evaporitic platform.

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General Session

Oral presentation

Sedimentology and stratigraphy of proximal alluvial-fan to dry mudflat deposits: evolution of the syn-rift series of the Berrechid sub-basin (Morocco)

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The Berrechid sub-basin encompasses a comprehensive record of the opening history of the Central Atlantic Margin. Through the examination of outcrops, core boreholes, and subsurface data, a sedimentological and stratigraphic study has been carried out, leading to the identification of eight lithofacies (LF) and the proposition of a new depositional model. The allogenic and autogenic processes controlling the deposition of each lithofacies within its stratigraphic context were also analyzed.

The sedimentation, which shows a fining upward trend from conglomerate to sandstone to siltstone lithofacies (LF.1, LF.2, and LF.3, respectively), with varying thickness from the edges to the center of the sub-basin, suggests that depositional environments transitioned from proximal to distal alluvial-fan systems. The evaporite lithofacies (LF.4) are likely to have formed in a saline lake environment. These lithofacies constitute the Lower Salt–Mudstone Fm, mainly controlled by the reactivation of the inherited network of NNE–SSW to NE–SW normal faults and the climatic fluctuations through the rift initiation stage during the Norian–Rheatian time.

The two basaltic lithofacies (LF.5 and LF.6), part of the Central Atlantic Magmatic Province lava flows, interrupt the syn-rift infill. The evaporites (LF.7) and siliciclastic mudstones (LF.8) which constitute the Upper Salt–Mudstone Fm are interpreted to be the result of a lateral migration from shallow saline brines to wet saline mudflat, to ultimately dry mudflat environments. This interpretation is supported by the existence of primary and diagenetic features indicating that all the identified lithologies have registered periods of flooding, evapoconcentration, and desiccation. The absence of distinctive marine lithologies and the lack of carbonates are additional evidence. The deposition of these lithofacies during the late stage of the rifting was governed by the ongoing subsidence, the sediment supply, and the fluctuations of the water table.

Overall, this study highlights the interaction between tectonic activity and climate change, which modulated the rifting and sedimentation of the Berrechid sub-basin. These findings enhance our understanding of the evolution of the Moroccan Central Atlantic Margin during the Norian–Rheatian–Hettangian.

Theme 10. Evaporites

General Session

Oral presentation

Evolution of the post-rift evaporitic section in the Red Sea basin

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The sedimentary section in the Red Sea basin (RSB) consists of Oligocene–Early Miocene rift sediments, overlain unconformably by post-rift Middle Miocene–Pleistocene sediments, mainly evaporites. This study focuses on the post-rift sedimentary section, combining the interpretation of seismic surveys with biostratigraphic and Sr isotopic analysis of well samples.

The evaporite sequence consists of a mobile Middle Miocene salt layer overlain by syn-kinematic mini basins filled with layered evaporites (shale and anhydrite). Although micro- and nannofossils are generally absent, we report foraminiferal assemblages from shale layers within the salt. The presence of planktonic foraminifera *Foshella fohsi* constrains the end of the salt deposition to the Serravallian. Additionally, the $^{87}Sr/^{86}Sr$ isotope composition of anhydrite and limestone in the layered evaporites constrains the end of salt deposition at 13.2 ± 0.5 Ma. The age of the Middle Miocene salt is therefore constrained between 14 and 13.2 ± 0.5 Ma, coincident with the start of seafloor spreading.

The evaporitic phase throughout the Red Sea was terminated by an angular unconformity observed on seismic data. The age of this unconformity is constrained by our Sr isotopic dating of carbonates and anhydrite between 6.2 and 8.9 ± 0.5, which corresponds to the Messinian salinity crisis (MSC). Moreover, the observed age gap of 2.7 Ma between the evaporites and the oldest Pliocene limestone supports the theory that the Red Sea was entirely disconnected from the Mediterranean during the MSC and possibly desiccated.

At the start of the Pliocene, the RSB was flooded with seawater from the Gulf of Aden, and normal marine sedimentation resumed. Seismic data demonstrate that reef buildup was controlled by salt withdrawal from the margins. Keep-up reefs started growing along the shoreline, aggrading as they glided into deeper waters above the salt detachment. The oldest reef limestone from the base of a 700 m thick platform was dated by Sr isotopes at 5.5 ± 0.5 Ma.

This study calibrates the poorly dated post-rift stratigraphy of the RSB, indicating rapid deposition of salt coincident with oceanization, and the end of evaporitic deposition by the MSC. Finally, we dated the oldest carbonates pointing to the flooding of the previously desiccated basin with seawater from the Gulf of Aden.

Theme 10. Evaporites

General Session

Oral presentation

Evaporites in the Danakil depression: a recent analogue for salt giants?

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Salt giants are unique features of the geological record but remain poorly understood due to the absence of modern analogues. The origin of ancient evaporites and their highly variable sedimentation rates are often debated. The Danakil rift basin in northern Afar features several hundreds of meters of evaporites with deposition still going on nowadays. Within this perspective, it represents an unrecognized modern salt giant analogue. This study focusses on the multi-proxy analysis (macro- and microfacies, XRF, XRD, micropaleontology, organic matter) of a 625 m deep core in the central part of the basin. The core record, dominated by halite with subordinate clastic sediments, reveals the Upper Pleistocene to Recent geological history of the basin. Siliciclastic sediments at the base of the core represent the last Red Sea incursion in the basin. On top of this unit, more than 100 m of halite and potash minerals are precipitated from marine brines. After basin closure, the recycling of marginal halite by meteoric waters, lead to the deposition of more than 100 m of nearly pure halite in the subsiding central part of the basin. The upper part of the core is characterized by alternations of clastic material and evaporites deposited in salt pan and lacustrine environments. Results evidence that thick evaporite deposits can form in a very short period of time by the evaporation of meteoric and seawater with only minor deep hydrothermal influence at basin scale. This has important implications for the understanding of older fossil salt giants.

Theme 10. Evaporites

General Session

Oral presentation

Evaporites from the Bresse Basin (France) across the Eocene–Oligocene transition

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In the Paleocene, the inception of the Western European rift system was coeval to the formation of the South Pyrenean foredeep forming a series of north–south elongated basins including the Bresse, Valence and Rhine basins. The Bresse Basin (France) is a N–S trending, tectonic depression (30–60 km wide, 200 km long) formed between the mid-Eocene and the Miocene. Most of the evaporites (~1300 m thick in the basin center), deposited within the Bresse Basin during the Late Eocene (Priabonian) and the Early Oligocene (Rupelian), have been to date interpreted as continental in origin, mainly due to the absence of paleontological and/or sedimentological evidence of marine conditions. However, halite deposits bromide concentrations suggest that halite likely precipitated from seawater, probably in a shallow brine environment judging from halite-crystal growth textures (inclusion-rich chevrons). In turn, reappraised pollen grain analyses highlight a significant change of regional vegetation cover during the Eocene–Oligocene Transition (EOT), as inferred from the waning of subtropical elements and the predominance of steppe taxa after the EOT, along with regular occurrences of Avicennia implying the development of a mangrove at times along the basin shores. Hence, the Paleogene evaporitic series of the Bresse Basin represent a crucial sedimentary record to understand how terrestrial environments reacted to the most contrasted climate transition of the Cenozoic era. New sedimentological and geochemical data including Sr, S, Cl isotopes have been conducted on both carbonates and halite deposits with the aim to unravel the complex hydrological and geochemical evolution of the Bresse evaporitic basin. Preliminary results reveal, from a chemical point of view, that Late Eocene halite deposits likely originated from marine-derived water, but that later mixing brine-reaction processes occurred with recycled solutes from both hydrothermal and riverine sources playing an important role as basin restriction increased.

Theme 10. Evaporites

General Session

Oral presentation

Unconventional hydrocarbon potential of self-sourced tight marlstone in evaporative lagoon: a case study from Triassic Leikoupo formation in the central Sichuan Basin

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Evaporative lagoon is rarely considered as hydrocarbon exploration targets, however, a breakthrough was made in tight marlstone reservoirs from evaporative lagoon in the Leikoupo Formation (Lei3-2) in the central Sichuan Basin. Source rock characteristics, reservoir characteristics of the marlstone and geochemical parameters of the oil and natural gas were investigated to evaluate unconventional hydrocarbon exploration potential of the tight marlstone from evaporative lagoon. The results reveal that the source rocks are deposited in evaporative lagoon environments and the average total organic carbon (TOC) content value for the samples is 0.75 wt%. Thermal maturity of organic matter is relatively high with calculated vitrinite reflectance (Rc) of 1.7%. The characteristics of marlstones suggest that the potential source rocks have fair to good hydrocarbon generative potential. The condensate samples have low densities, low viscosities and high thermal maturity with Rc value of 1.7%. Diamondoid hydrocarbons concentrations are relatively high, exceeding the baseline significantly, suggesting that oil cracking was occurred and natural gas was generated. For the natural gas, it is characterized by oil cracking gas with thermal maturity of 1.7%, and dry coefficient is around 0.90, carbon isotopic composition of methane and ethane is -41.3‰ and -28.4‰, respectively. According to the carbon isotopic compositions, thermal maturity and geological background, the oil and natural gas from Lei3-2 are comparable with the marlstone of Lei3-2. Thus, the oil and natural gas is self-sourced and origin from the marlstone in the Lei3-2. Micro pores and micro fractures are often detected in the marlstone from Lei3-2, and gypsum layer is conducive to the hydrocarbon preservation. These results suggest that the evaporative lagoon facies in Lei3-2 have large self-sourced unconventional tight marlstone reservoir potentials. This study also enhances the prospects for further oil and gas exploration of evaporative lagoon facies in other basins.

Theme 11. Biochemical and biological processes in sedimentary rocks

Special Session 11.1. Carbonate biomineralization processes, biominerals, environmental mineralogy/geochemistry

Oral presentation

Exploring biominerals' formation in extreme environments: from terrestrial hot spring to sulfuric acid system.

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During the first two billion years the prokaryotes were the major form of life on Earth. These microorganisms dominated the Earth surface and played important roles in biogeochemical cycling and Earth and life evolution. Microbes have the potential to dissolve and precipitate minerals and also act on lithification processes. Therefore, understanding the mechanisms of biomineral formation and diagenesis will provide important insight concerning the role of microbes in mineral nucleation and growth. The approach which utilize modern environments, where biomineralization takes place, open the possibility to: 1) improve our understanding of the impact of life on the Earth's systems and its permanent imprint in the geological records and, 2) provide knowledge to be used in medical, environmental and materials sciences.

An interdisciplinary investigation on modern carbonate hot spring systems (Tuscany, Italy) and sulphuric acid environment of an abandoned mine (Sardinia, Italy) have been performed. The unique occurrence of authigenic minerals in association with microbial communities in the study areas, acted as classical natural laboratories providing the opportunity to evaluate bio-geochemical and physicochemical factors that have direct influence in mineral precipitation. Using traditional and new tools from a sedimentary, petrographic, geochemical, mineralogical and geomicrobiological perspective integrated with high resolution techniques, it was possible to: 1) unequivocally identify different types of biominerals; 2) define their morphological features and composition linked to biotic compounds, 3) document nucleation processes, growth and diagenesis, and 4) provide 3D microscale visualization of the organomineral complex.

This investigation confirms the existence of a direct link between biological activities, degradation of organic matter and biomineral formations. Filamentous bacteria, virus-like particles and extracellular polymeric substances are the main sites where minerals nucleate and grow. The very early stage of mineralization consists into inorganic nanoparticles that gradually coalesce to form well-developed crystals. At larger scale, the microbial community interfaces with the environmental abiotic factors to form peculiar sedimentary bodies.

Theme 11. Biochemical and biological processes in sedimentary rocks

Special Session 11.1. Carbonate biomineralization processes, biominerals, environmental mineralogy/geochemistry

Oral presentation

Paleoecological significance of serpulid abundance along Barremian carbonate deposits (W Portugal): geochemical clues

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The conspicuous abundance of serpulid colonies occurring in specific intervals within Barremian coastal deposits of the Lusitanian Basin, W' Portugal is investigated. The goal is to unlock the paleoenvironmental conditions favouring their occurrence, test their potential as archives of past ocean chemistry and usefulness as markers of syn to post-depositional processes. For this, high-resolution petrographic, mineralogical and geochemical characterization is performed on serpulid tubes, tube fillings, other skeletal remains, encasing matrix and late diagenetic features. Modern equivalents are also explored. High-resolution (SEM-EDS) petrography and elemental point analysis revealed similar elemental compositions for modern and ancient tubes: magnesian calcium carbonate with traces of Al and Si. This supports the notion that the contribution of detrital aluminosilicates is of relevance during biomineralization. In contrast, modern and ancient bivalve shells from the same sites do not mirror this effect, suggesting differentiated mineralization pathways. Modern and ancient tubes show persistent minor differences in Mg content (3 wt% and 1 wt%, respectively). Reduced Mg content in fossil tubes is consistent with (at least) the early diagenetic stabilization of Early Cretaceous calcareous tubes into a more stable low-Mg calcite form. Later processes need to be evaluated using other proxies. Bulk mineralogical analysis of matrix micrite samples collected along a 2 meters stratigraphic interval, including a serpulid-rich horizon, was performed by X-ray powder diffraction (XRD). Semi-quantitative analysis of bulk mineralogical composition revealed a decreasing trend in quartz content from 50% at the base to complete absence towards higher levels. Continental influence is therefore reduced along this stratigraphic sequence, from significant to negligible. Complementary information obtained from other proxies will provide new evidence to refine the current findings. Namely, more precise ecological parameters as water-mass density (salinity and/or temperature), hydrodynamic patterns, turbidity, productivity (among others) will allow establishing the main driving forces promoting widespread serpulid development and highlight their potential as eco-stratigraphic markers.

Theme 11. Biochemical and biological processes in sedimentary rocks

Special Session 11.1. Carbonate biomineralization processes, biominerals, environmental mineralogy/ geochemistry

Oral presentation

Microbially-controlled formation of methane-derived, shallow-marine thrombolites from the Outer Carpathians

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Unusual methane-related limestones from the Outer Carpathians have been petrographically and isotopically investigated. These limestones show a clotted fabric, made of microcrystalline groundmass (MG) and cement-filled cavities (CFCs). MG is developed as digitate branching structure composed of peloidal/clotted micrite cemented by intergranular microspar, with abundant sponge spicules. It shows depleted $\delta^{13}C$ values (>-34‰) and hosts microtubes (< 5mm wide) filled with isopachous calcite also with depleted $\delta^{13}C$ values (>-39‰). The groundmass exhibits concentric banding around the microtubes that are located in the axial parts of individual MG digits. Such MG structure with clotted fabric strongly resembles thrombolitic facies. The strongly ^{13}C-depleted isotope signature suggests that the biologically-mediated anaerobic oxidation of methane induced thrombolite formation and that the microtubes acted as conduits for methane-rich fluids. CFCs are composed of slightly elongated (up to 100 µm), randomly oriented, interlocking calcite crystals. They show relatively high $\delta^{13}C$ >-15‰ and low $\delta^{18}O$ values >-9‰ possibly reflecting the influence of meteoric water. CFCs are often rimmed by massive pyrite with recrystallized framboidal fabric, probably formed due to bacterial sulfate reduction. Preliminary palynological analysis showed the presence of well-preserved dinocysts and spores of Lower Cretaceous age, interpreted as deposited in a coastal lagoon with strong terrestrial influences. The association of petrographic observations, stable carbon isotopes data, and palynological analysis suggests that the studied limestones can be interpreted as thrombolites formed in association with a cold seep in a shallow marine environment. Thrombolitic seep carbonates have rarely been reported, so this work might provide a new perspective on such association.

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Theme 11. Biochemical and biological processes in sedimentary rocks

Special Session 11.1. Carbonate biomineralization processes, biominerals, environmental mineralogy/geochemistry

Oral presentation

How well does organic matter survive in hot springs?

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Microbial carbonaceous organic matter from three actively precipitating travertines in Viterbo, Italy, was examined to investigate how the structure of the organic matter changes during (thermal?) degradation. Carotenoid pigments were the focus of the study as they provide some of the most common exclusively biogenic markers on Earth. Carotenoids are photosynthetic and photoprotective pigments that only biological processes can synthesise and are found in a wide variety of microorganisms including prokaryotes and eukaryotes. Raman spectroscopy can be used to identify carbon and carotenoids quickly and accurately in the samples through the inelastic scattering of laser light. However, we will show here that the Raman spectra of carbonaceous organic matter found in hot spring bacterial assemblages can exhibit overprinting of the carotenoid spectrum by the carbon spectrum. This happens as the organic matter progressively breaks down with increasing thermal maturity. This means key carotenoid biogenic signatures in hot-spring deposits may be hidden within carbon spectra. This study of carotenoid and carbon Raman spectra may help develop processes that assist in positively identifying truly biogenic carbon in ancient hot spring deposits. Understanding how the Raman spectra of organic matter can change in the geological environment has consequences for current and future planetary geology missions.

Theme 11. Biochemical and biological processes in sedimentary rocks

Special Session 11.1. Carbonate biomineralization processes, biominerals, environmental mineralogy/geochemistry

Keynote lecture

The role of clay minerals in bacterially-mediated eogenetic siderite cementation in the Missourian clastic rocks of the Anadarko Basin, U.S.A.

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This research investigates the process of siderite cementation in mudstone, which has historically received less attention compared to sandstone. Siderite cementation is an important factor in early diagenetic and maturation studies of sedimentary basins, and this study collected 40 samples of siderite-cemented sediments from two cores in the Anadarko Basin, with each siderite sample accompanied by adjacent mineralization-free sediment. The samples underwent various analyses, including microscopic, spectroscopic, and stable isotopes. The results revealed two types of siderite cementation patterns: bands and concretions, with concretions found in mudstone and mud intraclasts within sandstone, while bands were observed solely in mudstone. This suggests siderite cementation had strong preference for clay-rich domains. Bacteria-derived nanoglobules were documented within both types of cementation, revealing two stages of siderite mineralization. The first stage was biotically facilitated by microbial Fe-reduction processes, taking place near the sediment–water interface and leading to the occurrence of Fe-rich nanoglobules that transition to individual Mg-rich siderite crystals at their rims. The second stage operated at a depth of around 1.1 km and was marked by rhombohedral siderite indicative of an abiotic origin. The formation waters must have become enriched in Mg as the microbial Fe-reduction process ceased, explaining the compositional shift. This study provides insights into how bacteria control sediment eogenesis and adds information to the diagenetic evolution of Anadarko Basin sediments.

Theme 11. Biochemical and biological processes in sedimentary rocks

Special Session 11.1. Carbonate biomineralization processes, biominerals, environmental mineralogy/ geochemistry

Oral presentation

Elements, isotopes and small shelly fossils characteristics from Late Ediacaran to Early Cambrian in the northwestern Sichuan Basin: implications for stratigraphic correlation and co-evolution of life and environment

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Late Ediacaran to early Cambrian interval is one of the most significant transitions in Earth history, involving life explosion, supercontinent breakup, and marine redox changes. And it is a crucial period to understanding life, tectonic and environmental evolution on Earth. Elements, isotopes and small shelly fossils characteristics were investigated to discuss stratigraphic correlation and co-evolution of life and environment from late Ediacaran to early Cambrian in the northwestern Sichuan Basin. The results reveal that small shelly fossils can be detected in the high phosphorous section mainly ranging from 2% to 8%, suggesting that this interval belong to the early Cambrian, which is also consistent with the carbon isotopic composition results. It can be proposed that Maidiping Formation of Lower Cambrian is characterized by high phosphorus content and the lower part of the high phosphorus section belong to the late Ediacaran. The Ediacara–Cambrian transition is a large-scale deposition of global marine phosphorus. Phosphorus is an important factor in the prosperity of organisms and provides conditions for the prosperity of small shelly faunas and algae. Furthermore, biochemistry plays an important role in phosphorus deposition at the same time. In addition, Ediacaran–Cambrian boundary has many carbon isotope excursion events and specific small shell fossils. However, the Early Cambrian are denudated in the Sichuan Basin due to tectonic movement, some isotopes and small shell fossils characteristics are different from those in other basins. Thus, carbon isotopes and small shelly fossils could provide new evidence for tectonic evolution, though they are commonly considered to apply for stratigraphic correlation. The data exhibited in this study illustrates that phosphorus, isotopes, and small shell fossils can be combined to correlate the late Ediacaran to early Cambrian strata, and the results offer some new insights for the tectonic–depositional–environmental–biological synergistic evolution in the late Ediacaran to early Cambrian transition.

Theme 11. Biochemical and biological processes in sedimentary rocks

Special Session 11.1. Carbonate biomineralization processes, biominerals, environmental mineralogy/geochemistry

Poster presentation

In vitro microbial micritization of shallow marine carbonate grains

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The genesis and diagenesis of carbonate grains are widely investigated due to their importance as reservoir rock, especially in the Middle East (Volery et al., 2009). Micritization is an early diagenetic process in which parts of carbonate grains are reworked to cryptocrystalline textures and, hence, impacts the evolution of porosity in the later diagenetic stage (Bathurst, 1966). Microbes play an active role in the micritization process, by dissolving and recrystallizing carbonate skeletal and non-skeletal grains. Here, we evaluate the impact of microorganisms on altering the texture and geochemistry of carbonate grains from shallow marine environments. Culture experiments were conducted using different carbonate substrates and microbial strains (heterotrophic and phototrophic) isolated from the surficial sediment of Al-Kharrar Lagoon in the Red Sea, Saudi Arabia. Experimental solutions mimic the chemistry of the Red Sea water composition. The substrates were analysed by XRD, SEM-EDS, and ICP-OES. Results from heterotopic culture experiments showed dissolution and recrystallization in the surface, and more specifically in the contact area between grains. Moreover, new micrite was formed bonding the grains and composed of Mg-calcite. Recovered substrates, from phototrophic culture experiments, were embedded in a thick organic film with associated nanoaggregates of carbonate crystals. Textural changes such as porosity and surface roughness of the grains were also noticed. Sr/Ca ratio (0.023 mM) in the final solutions, was higher than in starting solution (0.011 mM). No significant change was observed in the metals concentration (Mg and Sr) of the substrates, indicating that little or no chemical disequilibrium existed in the system, which could thrive the geochemical alteration of the carbonates. Our experiments have so far demonstrated that different microbial pathways can actively increase the microporosity in carbonate grains and promote the formation of micrite.

References

Bathurst, R.G.C. (1966): Boring algae, micrite envelopes and lithification of molluscan biosparites. Geol. J., 5.
Volery, C., Davaud, E., Foubert, A., Caline, B. (2009): Shallow-marine microporous carbonate reservoir rocks in the middle east: Relationship with seawater Mg/Ca ratio and eustatic sea level. J. Pet. Geol. 32, 313–325.

Theme 11. Biochemical and biological processes in sedimentary rocks

Special Session 11.1. Carbonate biomineralization processes, biominerals, environmental mineralogy/geochemistry

Poster presentation

Microbial and geochemical signals related to micritization of carbonate grains in the shallow marine Al-Kharrar Lagoon in the Red Sea, Saudi Arabia

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Microbes are recognized for their participation in generating and lithifying sediments, however, their contribution to the micritization of sedimentary sequences is still poorly understood. Micritization is a post-depositional process in which the original carbonate fabric is altered to cryptocrystalline textures, and involves dissolution and re-precipitation of carbonate minerals (Bathurst, 1966). A multidisciplinary approach combining petrographic, mineralogical, and geochemical with metagenome analyses have been used to study early diagenetic processes, such as micritization, in a sedimentary sequence from Al-Kharrar Lagoon in the Red Sea, Saudi Arabia. Thin section petrographic analysis reveals extensive microboring and associated micritization in the sediments. The sediments are mainly dominated by albite (~ 4%), aragonite (~74%), high Mg-calcite (~13%), calcite (~2.4%) and quartz (~2%). Dolomite, siderite, gypsum, and halite are also present (<2%). The geochemical analyses show a negative correlation between Sr^{2+} and Mg^{2+}, suggesting a replacement of aragonite by Mg-rich carbonate minerals such as high-Mg-calcite and dolomite. SEM images show the presence of microboring in the carbonate grains and an organic film (e.g., EPS) embedding the sediment. The microbial taxonomic groups as the phylum *Chloroflexi* show an increase in percentage with depths and the family *Desulfobacterota* is largely distributed throughout the sediment and more abundant in the upper layers, while cyanobacteria are found in the surficial layers. These microorganisms are related to carbonate precipitation and microboring mechanisms. Micritization of marine carbonate grains is a well-known early diagenetic process, however, the mechanism involved in this process remains unclear. The present work is an attempt to understand the micritization of shallow marine carbonates and, thus, to shed new light on the fundamental questions concerning the changes in the permeability of carbonate rock reservoirs.

Reference

Bathurst, R.G.C. (1966): Boring algae, micrite envelopes and lithification of molluscan biosparites. Geol. J. 5.

Theme 11. Biochemical and biological processes in sedimentary rocks

Special Session 11.1. Carbonate biomineralization processes, biominerals, environmental mineralogy/geochemistry

Poster presentation

Multi-proxy evaluation of oyster-shell alteration: implications to paleoenvironmental reconstructions and age-assigning efforts of ancient coastal deposits

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Oyster shells are widely used as archives of past environmental conditions, being equally useful for dating and correlation purposes in coastal depositional sequences. Based on a selection of well-preserved to poorly-preserved specimens collected at two mid-Cenomanian coastal lagoon settings (W Portugal), a multi-proxy approach included cathodoluminescence imaging, C and O-isotope analysis, elemental concentration data and Sr-isotopic analysis. The goal is to explore the impact of variable degrees of diagenetic imprint (mild to pervasive) on the geochemical record of shallow-marine skeletals and test the limits of their suitability for paleoenvironmental interpretations and age-assignment via Sr-isotope ratio. Restricted to more open-lagoonal phases were interpreted based on palaeoecological data. Complementing cathodoluminescence inspection, elemental and isotopic (C and O-ratios) were used as diagenetic screening tools. Iron and Mn were the most effective tracers of mild degrees of diagenetic overprint. Well-preserved specimens show a low abundance (Fe<300; Mn<50 ppm), followed by the moderately-preserved shells and Fe- and Mn-enriched shells are classified as poorly preserved (Fe>700; Mn>150 ppm). In contrast, skeletal Sr and Mg concentrations did not correlate well with increasing diagenetic influence. Most selected specimens displayed a narrow range of Sr concentrations from 750 to 950 ppm, except for one moderately-preserved sample showing slightly lower values (550 ppm). Interestingly, no relation was identified between Sr abundance and Sr-isotope ratio. Mg elemental concentrations were noticeably persistent for most samples, from 1500 to 1750 ppm. When compared to elemental concentrations, carbon and oxygen isotope data were less responsive to early-stage, shallow burial diagenetic alteration. Evidence of facies control on the preservation degree of the studied specimens was found. Accordingly, altered specimens were persistently retrieved from deposits corresponding to restricted lagoon intervals or short-lived marine lagoon periods. Only the best-preserved oyster shells provided reliable Sr-isotope ratios and corresponding ages, refining previous lateral correlation efforts between sections and interpretations on local palaeo-shoreline configuration.

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Special Session 11.1. Carbonate biomineralization processes, biominerals, environmental mineralogy/ geochemistry

Poster presentation

Dolomite formation in Salinas lagoon, Alicante (Spain)

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Dolomite is very abundant during the Precambrian, while is rarely observed in marine modern environments, despite the fact that modern sea water is oversaturated with respect to dolomite formation by one to two orders of magnitude (Vasconcelos & McKenzie, 1997). Recent dolomite precipitation has mostly been found to occur in hypersaline lacustrine and coastal environments, where its formation has been related to microbial activity (Sánchez-Román et al., 2009). Hence, we aim to study the formation of dolomite in modern playa lake environments, concretely, in Salinas lagoon, Alicante (Spain) Our results show that Salinas lagoon sediment is composed up to 96 % of dolomite with $\delta^{13}C$ and $\delta^{18}O$ values ranging from -5.12 to -1.53 ‰ and from -1.54 to 6.48 ‰, respectively. Salinas lagoon sediment which contains both calcite and dolomite presents $\delta^{18}O$ values smaller (on average 1.59 ‰) than that which only contains dolomite (on average 4.60 ‰). $\delta^{18}O$ is considered as a proxy for precipitation/evaporation ratio, more positive values (enriched in the heavy isotope ^{18}O) might indicate stronger evaporation (arid conditions), although input from rainfall and/or meteoric water should be also considered. Scanning electron microscope (SEM) images of Salinas lagoon sediment show rod-shaped bacterial cells are attached to the surface of the dolomite crystals. We conclude that during arid periods, the evaporation/precipitation ratio is higher, resulting in higher salinity and concentration of Mg^{2+} in lake, promoting the growth of halophiles (salt-loving microorganisms) and the precipitation of dolomite.

References

Sánchez-Román M., Vasconcelos C., Warthmann R., et al. (2009): Microbial dolomite precipitation under aerobic conditions: results from Brejo do Espinho Lagoon (Brazil) and culture experiments. Perspectives in carbonate geology: a tribute to the career of Robert Nathan Ginsburg, 167–178.

Vasconcelos C., McKenzie J.A. (1997): Microbial mediation of modern dolomite precipitation and diagenesis under anoxic conditions (Lagoa Vermelha, Rio de Janeiro, Brazil). Journal of sedimentary Research, 1997, 67/3, 378–390.

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Poster presentation

Carbonate formation in a playa-lake system, Laguna Fuente de Piedra, Spain

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Carbonate minerals act as archives to reconstruct the biogeochemical conditions under which they formed. However, formation of mixed cation carbonates specifically dolomite under low temperature conditions remains a long-standing enigma because of its high abundance in Precambrian rocks and rarity in modern settings. We investigate a sedimentary record that originates from Laguna Fuente de Piedra (LFP), an arid, hypersaline, isolated playa-lake system in SW Spain, spanning a time range from the present to the Pleistocene/Pliocene Epoch. LFP is hosted within a series of Triassic evaporites, Jurassic carbonates and Miocene deposits (Höbig et al., 2016). These lacustrine sediments alternating with microcrystalline gypsum and organic-rich mud layers result in a range of minerals: calcite, Mg-calcite, aragonite, with an increase in Fe-rich dolomite content up to 93% with depth, associated with sulphates, clays and quartz. Stable oxygen isotopes ($\delta^{18}O$) and radiogenic strontium isotopes ($^{87}Sr/^{86}Sr$) indicate the paleotemperature and salinity, resulting in a correlation between lower $^{87}Sr/^{86}Sr$ values ranging between (0.70816 and 0.70829) and higher $\delta^{18}O$ values (from 1.46 to 6.61‰) indicating a brackish-water origin, and possibly strong evaporation. Light $\delta^{13}C$ values (from -5.83 to -2.89‰) of the Fe-rich dolomite could be a result of the mixture of different carbonate sources from the surrounding (Höbig et al., 2016). In this study, SEM images from LFP sediment provide a solid insight on the microbial origin of the dolomites, showing wired microbes, bacterial voids, extracellular polymeric substance (EPS), spherical structures, and nanocrystals. Furthermore, the microbial activity is linked to high trace element concentrations of Mn^{2+} (from 341 to 1689 ppm) and Fe^{2+} (from 143 to 3023 ppm). The characterization of this modern natural setting can help understand carbonate formation not only in modern environments but also in the geological past of Earth and Mars.

Reference

Höbig, N., et al. (2016): Palaeohydrological evolution and implications for palaeoclimate since the Late Glacial at Laguna de Fuente de Piedra, southern Spain. Quaternary International, 407, 29–46.

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Poster presentation

Microbial mediated micritic cements in Upper Pleistocene (MIS 5e) mid-latitude shallow marine carbonate deposits (Taranto Gulf, south Italy)

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Warmer conditions and higher sea level than at present are inferred for the Last Interglacial (MIS 5e 135–116 ky), that is regarded as a good analog of near-future Earth climate in response to the global warming. MIS 5e deposits outcropping along the Taranto Gulf are mainly constituted of few meters thick bioclastic calcarenite layers, representing a locally vegetated infralittoral sandy bottom, characterized by relatively high-energy bottom conditions. They are affected by very limited post depositional diagenesis that allowed to study early marine cementation processes. Clasts mostly consist in medium to coarse sandy size skeletons and fragments of skeletons of a variegated biota together with mainly large mollusks shells that inhabited the sediment and a very minor amount of siliciclastic. Micritization variably affect most of the bioclasts while cements show a microcrystalline texture with various micro-morphologies and fabrics: not-isopachous aphanitic and filamentous rims, vacuolar peloidal meniscus, aphanitic micro-mounds, and aphanitic porosity-filling matrix. Despite different fabrics, cements are constituted by sub-micron sized anhedral to nonospheroidal crystals of low Mg calcite, mixed with a minor amount of irregular platy crystals of saponite. All fabrics of cement are rich of mineralized filamentous, tubular and sub-spherical bacteria bodies that implies the synsedimentary presence of a microbial community forming an epilithic to endolytic biofilm that stabilized the incoherent sediment, and mediated the early precipitation of the cements. A similar process of microbial induced micritic cementation has been observed in tropical carbonate platform realms, that could suggest similar climate conditions for the mid-latitude studied deposits.

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Poster presentation

Viruses occur involved in biomineralization of travertines

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Viable and mineralized viruses have been found in several natural calcium carbonate precipitating environments. These include marine microbial mats and freshwater biofilms associated with tufa deposits, where in both cases viruses are likely to have a significant impact on the process of bio-mediated carbonate precipitation. Importantly, laboratory experiments have confirmed the ability of viruses to mediate calcium carbonate precipitation. Here, viruses are identified in the biofilms associated with active travertine surfaces of deposition at the Roman Bath, Bath (UK), Bešeňová (Slovakia), Bullicame and Terme di Saturnia (Italy), Egerszalók (Hungary), and Pamukkale and Karahayit Kizilsu (Turkey) sites. Biofilm samples were collected in the spring of 2020, 2021 and 2022.

The temperature of the water precipitating the analysed travertines ranges from 14.6^{0}C (Bešeňová) to 67^{0}C (Egerszalók) with pH between 6.2 and 7.4, respectively. The chemical composition of the thermal waters is chiefly a Ca-HCO_3 saturated system with various admixtures of major and minor elements dependent on the sampling site. TEM images of the biofilms reveal abundant 80–300 nm size particles that exhibit hexagonal and spherical shapes that are typical of the viral capsid-like morphology. These particles range from non-mineralized to fully mineralized and are commonly included in the bacterial EPS. Chemical composition of these virus-like particles indicates that initial mineralization occurs through amorphous Ca–Si rich phases, with less Mg and Al, that replace the organic substrate and eventually evolve to Ca-carbonate with minor silicates. They also contain a variable amount of N and P, even if fully mineralized, that suggest their likely biological origin. Metagenomic analysis of viruses performed on the total genomic DNA extracted from biofilms reveals that most viral strains belong to the bacteriophage families Myoviridae, Siphoviridae and Phycodnaviridae which are naked, tailed or tailless (Phycodnaviridae) viruses with icosahedral-shaped capsids; these features are consistent with the microscopic evidence of mineralized viral particles.

In summary, in addition to bacteria and EPS, viruses are also important contributors to the biomineralization processes in the formation of the analysed travertines.

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Poster presentation

Thriving buildup of microbialites as large-scale hydrocarbon reservoir linked to hypersaline lagoon during later Ediacaran to Middle Cambrian

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Microbialites related to microbial-mediated mineralization and microbial bond of sediments were widely developed in the Precambrian periods. At the end of the Neoproterozoic and the subsequent Cambrian period, macro-heterotrophic biota gradually flourished, grazing microorganisms as well as destroying buildups of microbialites, resulting in the gradual shrinkage of microbial communities (e.g. cyanobacteria) as well as microbialites. In what special environments could the microbialites still continue to develop in large quantities? The question is worth exploring. There are large-scale of microbialites, dominated by stromatolites and thrombolites in the Upper Ediacaran to Middle Cambrian in the Tarim Basin, northwestern China. According to mineralogy, petrography and geochemical analysis, it was identified that the environments favor for microbial communities and development of microbialites were hypersaline lagoons and lagoon edges. The evaporated high-salinity seawater in the lagoon inhibited the reproduction of macro-heterotrophic biota, thus favoring the formation of microbialites. In the open water slope facies far away from the lagoon, heterotrophic biota bred in large numbers, restricting development of microbialites. The high salinity seawater in the lagoon was also conducive to the microbial-mediated dolomitization, which promoted the widespread dolomitization of the microbialites. The dolomitized microbialites were further subjected to meteoric karstification and hydrothermal alteration along faults and fractures, so that they were rich in primary framework pores, intercrystalline pores and secondary dissolution vugs, and consequently become important hydrocarbon reservoirs. Several field outcrops reveal the pores and vugs in the Upper Ediacaran to Middle Cambrian microbialites contain large amount of bitumen. Ultra-deep drillings such as Well Luntan 1 and Well Tashen 5 successively obtained high-yield industrial gas flows in the Precambrian microbialite reservoir at a depth of more than 8,000 m. These large-scale microbialites developed in the hypersaline lagoon environments are potential reservoirs for hydrocarbon exploration at a depth of more than 10,000 meters in the Tarim Basin.

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Special Session 11.2. Trace fossils in sedimentological analysis: expanding their applicability in space and deep time

Oral presentation

Trace fossils from Miocene to Pleistocene tidal straits in southern Italy: implications for the ichnofacies model

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Ichnologic analysis in tidal environments has focused on tide-dominated estuaries and deltas, as well as on tidal flat-subtidal sandbody complexes. Conversely, tidal straits representing marine passageways between emerged lands that link two adjacent larger basins have received less attention from an ichnologic perspective. The Lower Pleistocene Messina and Siderno straits, and the Tortonian Monte Pellegrino Strait (Amantea Basin) in southern Italy, have been explored to evaluate their ichnologic content within the framework of tidal straits. These comprise three well-defined zones: (1) strait center, (2) intermediate zone (i.e., 'dune-bedded zone' of Longhitano), and (3) strait end. The intermediate zone, the most important in terms of sediment volume, is characterized by 3D and 2D dunes fields ('constriction-related delta' of Dalrymple). The intermediate zone is typified by rapid tidal currents, alternation of strong erosion and rapid deposition, organic particles kept in suspension by vigorous currents, sandy substrates, and well oxygenated bottom and interstitial waters. Influence exerted by waves seems to have been negligible in the observed facies. The ichnofacies model predicts that this zone would be characterized by the archetypal *Skolithos* Ichnofacies. However, elements of this ichnofacies seem to be restricted to scarce vertical burrow segments of *Ophiomorpha*. In contrast, large-scale, cross-bedded, coarse- to fine-grained sandstone in places contain abundant horizontal trace fossils assigned to the ichnogenera *Bichordites* and *Scolicia*, attributed to irregular echinoids, being locally associated with *Macaronichnus*. Colonization of these highly mobile substrates occurred at times of reduced current speed and pauses in sedimentation. An amensal relationship between the echinoderms and the producer of the vertical burrows may be invoked. This tidal depositional regime prevented construction of permanent burrows such as those that typified the *Skolithos* Ichnofacies. The studied association represents a departure from the ichnofacies paradigm, similar to the *Macaronichnus* association of the foreshore in wave-dominated shorelines. These new observations in tidal strait deposits suggest that the ichnology of tidal environments is more complex than previously envisaged.

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Oral presentation

Evolution of coastline depositional systems in a tropical forearc basin during the Oligocene–Miocene in the Colombian Caribbean: signals from well-cores integrative sedimentological, ichnological, and micropaleontological analysis

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Tropical latitudes with active margins are tectonic environments where multiple factors act on the development of coastal systems. Basin analysis from the Colombian Caribbean is particularly important given that the study the multiple factors that operate, provide possible further recognition criteria for mixed systems. Despite being basins with economic interest, their complex geological evolution, and the frequent lateral and vertical variation of sedimentary facies impede conclusive characterization until now. The studied successions correspond to onshore well-cores drilled in the Sinú–San Jacinto Basin. The integration of sedimentological, ichnological and micropaleontological data allowed us to characterize the evolution of the different sub-environments in thick coal-bearing mixed-energy nearshore siliciclastic successions from the Oligocene to Early Miocene. Two systems are distinguished taking into account the multi-tool analysis: (i): Oligocene, is represented by heterolithic deposits with moderate diversity of trace fossils (dwelling and escape trace fossils domain), high content in morichal pollen alternating with thin transgressive lags. It is interpreted as flood-forested delta plain and hyperpycnal-dominated delta front to prodelta settings punctuated by transgressive wave pulses, and (ii): late Oligocene to Early Miocene, is represented by high diversity trace fossils (dwelling and feeding trace fossils), coal-bearing thick fine-grained packages containing mangrove pollen with palaeosoils alternating with deposits showing the same facies associations than Oligocene. It is interpreted as an aggradational, well-developed, flood-forested delta plain system commonly sea-drowned during transgressions that allowed for developing a tracemaker community under mixed conditions. Minor order sequences into each interval (e.g., distributary mouth–bar channel prograding sequences) revealed short-term cycles presumably controlled by internal shoreline dynamic. Multidisciplinary analysis is essential to recognize the influence of river, wave and tide processes on tropical deltas where it is complex to establish dominant processes for long periods of time due a high spatial and temporal variability.

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Oral presentation

Variation in Lower Cretaceous coastline morphology and resulting depositional conditions along the Scotian Margin, Canada

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The onset of North Atlantic rifting along the Scotian Margin, offshore eastern Canada, began in the Middle Triassic, with eventual breakup with Gondwana taking place in the Early–Middle Jurassic. Resultant basins were filled by a predominantly siliciclastic passive margin succession. In particular, the Lower Cretaceous interval is characterized by strata from a variety of distal marine, shallow marine, and fluvial settings. In concert with ongoing palynological and other analyses, the present study contributes to an event stratigraphic scheme by focussing on paleoenvironmental and sequence stratigraphic interpretations. Ichnological and sedimentological analyses of conventional cores from two wells were used to build a facies model, with an initial focus on a 170 m-thick, relatively continuous succession of the Barremian to (?)lower Aptian Upper Member of the Missisauga Formation. Wave-dominated marine conditions initially prevailed, with oolitic sandy limestones and local distal *Skolithos* Ichnofacies assemblages. Successive restricted bay and deltaic deposits show an upward decrease in wave-dominance, with impoverished archetypal *Cruziana* Ichnofacies suites suggesting deposition in a wave-influenced estuary. Overlying sandstone bodies are mostly trough cross-bedded, but contain herringbone cross-stratification, cyclical bedding, wood with *Teredolites* borings, and locally highly impoverished *Skolithos* Ichnofacies suites; they are interpreted as a tidal channel to tidal bar succession. The concurrence of tidal channel-bar, tidal flat, barrier shoreface, and restricted bay facies, however, indicates deposition within a mixed wave- and tide-influenced estuarine setting. Deposition then shifted to the outer estuary, with barrier shoreface, tidal flat, and restricted bay deposits dominating the succession and characterized by impoverished *Cruziana* and local *Skolithos* Ichnofacies assemblages. The top of the Missisauga Formation shows a return to marine conditions with storm influence indicated by hummocky cross-stratification, weakly stressed *Cruziana* Ichnofacies suites, and more diverse marine macrofauna. Evidently, depositional conditions varied in the Early Cretaceous as a function of varying coastline morphology that can be linked to overall transgressive and regressive events.

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Oral presentation

Carbonate ichnology of the Early Eocene Naredi Formation, Kutch (Kachchh) basin, Gujarat, India: Evaluating paleo-environmental controls and biotic responses

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The Early Eocene Naredi Formation of Kutch basin is a classic example of a mixed siliciclastic–carbonate system developed in a restricted marginal to open shallow-marine setting. The transient global climatic aberrations during the Paleocene–Eocene interval, known as the hyperthermal events, have globally been recorded, which had a profound impact on the biotic assemblages and lithofacies association of this formation. The green, red, and brown shales beds in the succession are bereft of ichnofossils except in the facies-selective and impoverished trace-fossil suites at the nodular or concretionized layers. In contrast, the carbonate beds have high abundance of ichnofossils at specific intervals, where the bioturbation is restricted to the packstone layers. The intensely bioturbated lower packstone bed overlying the unbioturbated wackestone situated at the middle part of the succession manifests the *Nummipera*–*Cylindrichnus* ichnofabric (NCi) with a new species, *N. Saraswatii*. The bioherms, which are nestled within the unbioturbated packstone and also shows the NCi, occurs as the mounded aggregates of burrows produced by a coven of gregarious facultative worms. The upper packstone exhibits complete bioturbation with a monospecific softground *Thalassinoides* ichnofabric. The ichnofabrics of all these carbonate units show different depauperate expressions of the *Cruziana* Ichnofacies, as the impoverishment is imparted by their conspicuous paucispecificity, with increased preservation potential compared to the associated shale units. The wackestone and lower packstone units were deposited during the late Transgressive Systems Tract (TST) in a shoaling core-bank setting. The middle packstone hosting the bioherms and the upper packstone members developed in a semi-restricted back-bank depositional environment during the Highstand Systems Tract (HST). Recurrences of bioturbated carbonate intervals in an otherwise ichno-barren succession indicate transition from a restricted and stressed lagoonal condition to an open-shelf environment bearing the signatures of onset of the Early Eocene Climatic Optimum (EECO).

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Oral presentation

Ichnology of the "paleo-Brahmaputra" shelf-margin hyperpycnal-deltaic system from the Miocene Boka Bil–Tipam formations of the Chittagong–Tripura Fold Belt, Bangladesh

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The Miocene Boka Bil (BB) and the lower part of Tipam Sandstone (TS) formations, exposed along the Bandarban Structure of the Chittagong–Tripura Fold Belt in Bangladesh, demonstrates ichno-sedimentological signatures of a shelf-edge river-mouth system – attributable to the "paleo-Brahmaputra" shelf-margin delta developed near the foredeep of Indo–Burmese plate boundary. The Boka Bil (BB) Formation onsets with sand and silt beds deposited under hyperpycnal flow condition and associated large slump complexes as exposed in the Shaila Prapat area. This lower interval of the BB exhibits no bioturbation except rare and solitary occurrences of *Paleophycus* isp. along the Bouma $T_{b\text{-}c}$ units. The middle BB exposed along the N108 road cuts around the Meghla tourism complex is dominated by silty–sandy heterolithic deposits cut by massive sand-filled channels. The heterolithic units show a localized, impoverished, and low-intensity development of the *Rosselia* Ichnofacies with paucispecific combination of *Rosselia socialis*, *Lockeia*, *Teichichnus rectus*, and *Asterosoma*. The upper BB exposed along the Sangu River is marked by a coarsening- and thickening-up succession comprising swaley-cross-stratified sand (SCS) intercalated with silty to fine-grained sandy heterolithic and silty claystone units. The silty claystone units document an impoverished graphoglyptid suite consisting of *Protopaleodictyon*, *Urohelminthoidea*, *Dendrotichnium*, and *Helminthorhaphe* cast by combined-flow-rippled silty sand thin beds that contain a highly impoverished, localized, and later-formed suite of *Teichichnus rectus*, *Lockeia*, and *Paleophycus tubularis*. The sandy heterolithic units display high- to intense-bioturbation characteristic of archetypal *Rosselia* Ichnofacies with localized development of the crowded *Rosselia socialis* ichnofabric with a lam-scram appearance. The thick SCS beds show no bioturbation. The top contact of the BB is marked by intermittent appearance of channel cuts with rip-up clast-rich conglomeratic lag at the base. The overlying lowermost part of TS comprises massive to both low- and high-angle trough cross stratified medium- to coarse-grained unbioturbated sand megabeds and beds intermittently separated by sandy–silty heterolithic units with a highly impoverished *Rosselia* Ichnofacies.

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Oral presentation

The interplay of animal and plant life, landscape and sedimentation in a Devonian distributive fluvial system: evidence from the Hangman Sandstone Formation of SW England

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The Eifelian-aged Hangman Sandstone Formation of southwest England has become a key reference unit in sedimentary facies analysis. In its first detailed sedimentological interpretation, it was described as representing dryland alluvial sheetflood deposits, relatively barren of trace or body fossil evidence for ancient life. Since then, it has been considered archetypal of such dryland facies and used as a central facies model for the interpretation of other formations worldwide. The unit also has significance in the context of the 'Old Red Sandstone' (ORS) succession of northwest Europe, recording deposition on the Cornubian terrane and thus being notably different in its climatic context to other British ORS settings. Recent work on the unit has revealed several sedimentological and ichnological characteristics that challenge previous environmental interpretations of the unit, and new fossil and trace fossil discoveries reveal it to be a previously underappreciated window onto the diversification of life–sedimentary interactions in Devonian non-marine environments. In this talk we present evidence that the unit is better understood from the context of alluvial and lacustrine deposition within a distributive fluvial system, challenging its previous 'sheetflood' interpretation. We also reveal that the unit contains a notably diverse arthropod ichnofauna, comprising 25 different ichnotaxa, shedding light on arthropod–sediment interactions in the Devonian. In addition, an abundance of 'true substrates' in the unit provide evidence for varied arthropod walking and furrowing behaviour, in addition to several striking microbially-induced sedimentary structures, including mat roll-ups, desiccation and rip-up features. Finally, we show the unit to also yield an exceptional array of previously unreported vegetation-induced sedimentary structures and in situ plant fossils, which, combined with new sedimentary facies information, provide a high resolution window onto plant-related biogeomorphic sedimentary processes within some of Earth's earliest forests.

Theme 11. Biochemical and biological processes in sedimentary rocks

Special Session 11.2. Trace fossils in sedimentological analysis: expanding their applicability in space and deep time

Oral presentation

An ultra-stressed infaunal niche and ichnology of restricted xylic embayment setting from the early Eocene of western Kutch (Kachchh) basin

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The Eocene lignite deposits in the western Indian basins testify having their origin under a hyperthermal greenhouse condition. In the western Kutch (Kachchh) basin, the Panandhro, Umarsar, and Matanomadh depocenters evolved as the physiographically confined embayments that were flooded during the Early Eocene transgression(s). The opencast-mine sections consist of ca. 30 m thick sequence of alternating beds of lignite seams, organic-rich shales, and organic-poor silty claystones. An improved understanding of the recurrent fluctuations in benthic oxygen levels, ranging from the prevalent anaerobic to intermittent dysaerobic conditions, is provided by the ichno-sedimentological assessment. The lignitic horizons are unbioturbated representing complete euxinia. The organic-rich shale units comprises heterolithic laminae of organic-rich mudstone and mud-free organic debris that are rarely (BI 0–1) bioturbated with simple pyritized shafts (*Trichichnus* isp.). The lighter gray and laminated silty claystone units contain bedded/thin-bedded claystones with intermittent fine-grained siltstone laminae and sparse to low bioturbation (BI 1–2). The silty claystones consist of paucispecific suites with the following ichnotaxa: three ichnospecies of *Trichichnus*, an unnamed trace fossil with a mixed ichnofamilial affinity to Rosselichnidae and Siphonichnidae, *Phymatoderma*, and *Chondrites*. The silty claystone facies represents the fluctuating dysoxic-anoxic condition. Two disconformity surfaces are identified by the presence of *Teredolites* ichnofacies represented by *Thalassinoides* burrows into the firm peatgrounds. These surfaces delineate the bases of either the 6th-order transgressive or autocyclic erosional events in these embayments. An extremely suppressed softground suite in these deposits points towards prolonged oxygen depletion in a reducing low-pH setting connected remotely to open sea. The rare and paucispecific colonization indicates chemichnial and facultative generalists taking advantage of "episodic" and short-duration dysoxic events. The universal occurrence of the *Trichichnus*-type behavioral suite in the highly eutrophic / euxinic organic-rich softground conditions emphasizes classification of a new ichnofacies, *viz.*, *Trichichnus* Ichnofacies.

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Special Session 11.2. Trace fossils in sedimentological analysis: expanding their applicability in space and deep time

Oral presentation

Long-term sea-level changes and paleoenvironmental conditions: ichnological analysis of the Late Pennsylvanian Midcontinent Sea

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During the last phase of the Late Paleozoic Ice Age, the inner region of North America was mostly covered by a broad, shallow, epicontinental sea known as the Late Pennsylvanian Midcontinent Sea (LPMS). From the Middle Pennsylvanian to Early Permian, sedimentological dynamics in this region were heavily conditioned by subsequent transgressions and regressions of the sea, linked to cycles of melting and growth of Gondwanan ice sheets. This region accumulated cyclic sedimentary deposits known as cyclothems, consisting of (from bottom to top): transgressive limestones, highstand core shales, regressive limestones, and lowstand nearshore shales with paleosol caps. In this work, three successive cyclothems (Hertha, Swope, and Dennis; Missourian Stage, lower Upper Pennsylvanian) have been studied in five cores from two basins (Midcontinent Shelf and Illinois Basin) of the LPMS. An integrated sedimentological and ichnological analysis was conducted to determine the influence of long-term sea-level changes on seafloor paleoenvironmental conditions affecting the macrobenthic trace-maker community. The studied cyclothems reveal similar ichnoassemblages in both basins, consisting of three main ichnogenera ("Chondrites", "Planolites", and "Zoophycos") and un-classified horizontal burrows (UHB) grouped in four different ichnofabrics (sand-infill, mottled, light-on-dark, laminated). Within cyclothems, core shales contain UBH and the ichnogenera "Zoophycos" and "Chondrites", whereas nearshore shales are dominated by "Planolites". The similarities in ichnological composition contrast with the large lithologic differences between the basins, the Midcontinent Shelf being dominated by carbonates and shales, whereas the Illinois Basin hosts many more sand beds. These observations reveal the influences of sea-level changes determining variations in sedimentological conditions, strongly influenced by local paleogeography/topography, but indicate little impact on seafloor ecological parameters.

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Oral presentation

Burrow distributions in an active intertidal dune field in White Rock, British Columbia, Canada

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The distribution of burrows in sedimentary environments is strongly influenced by the environmental conditions present during sediment deposition. Despite being widely applied to the interpretation of sedimentary rocks, the relationship between burrow distributions and environmental parameters is poorly quantified. This study applies photogrammetric techniques to assess the factors that influence burrow distributions in an active intertidal dune field near White Rock, British Columbia, Canada. Using structure-from-motion and multi-view stereo algorithms, three-dimensional models were constructed, revealing that burrow distributions are strongly influenced by the position of sand dunes. In particular, the interdune areas display high population densities, whereas only isolated burrows are observed on the rippled dune crests. This bipartite distribution becomes less pronounced in the seaward reaches of the study area, where overall population densities are higher. These results indicate that endobenthic colonization is more prevalent in areas with minimal sedimentation, stable sedimentary substrates, high pore water content, and abundant food resources. This study highlights the use of burrow distributions to interpret environmental conditions, providing insight into the factors governing the occurrence and intensity of bioturbation in sedimentary rocks.

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Oral presentation

From grains to tracks: the role of substrate on the anatomical fidelity of dinosaur tracks (upper Stormberg Group, southern Africa)

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Tracks result from the interaction between the animal's foot and the sediment properties in which the tracks are registered. The track morphology is strongly controlled by the substrate, e.g., tracks registered in saturated versus under-saturated sediments would typically have low- and high-anatomical fidelity (or morphological quality), respectively. The upper Stormberg Group in the main Karoo Basin of South Africa and Lesotho is rich in Late Triassic–Early Jurassic tetrapod tracks that show variable anatomical fidelity within and between ichnosites. To quantify the role of substrate in the track anatomical fidelity and preservation potential, we examined the petrographic properties (e.g., grain size, grain shape, composition) of the sedimentary host rocks to complement the established macro-sedimentary geology at selected ichnosites. Our results show that: 1) very fine-grained sandstones preserve tracks with higher anatomical fidelity than coarser-grained sandstones; 2) track abundance is higher in fine-grained sandstones; 3) ichnosites preserving microbially induced sedimentary structures (MISS) are associated with tracks of higher anatomical fidelity, and 4) grain size decreases and roundness increases up stratigraphy. This increase in anatomical fidelity of tetrapods, notably theropod tracks from the Late Triassic to the Early Jurassic, may be attributed to our findings of a decrease in dominant grain size and an increase in roundness. However, the increase in track abundance and anatomical fidelity is likely also affected by 1) large-scale changes in the palaeoenvironment from meandering fluvial to aeolian–lacustrine settings (facies control); 2) a greater prevalence of MISS at the younger ichnosites; and 3) a population increase in trackmakers after the end-Triassic mass extinction.

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Oral presentation

The role of oxygen and substrate on trace-fossil distribution in the fine-grained Vaca Muerta Formation (Upper Jurassic–Lower Cretaceous, Argentina)

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In fine-grained deposits, benthic oxygen-deficiency and soupy substrates during deposition, combined with high compaction during diagenesis, preclude preservation of discrete bioturbation structures, hindering a clear assessment of paleoecologic conditions. The Vaca Muerta Formation of Argentina represents an excellent example to characterize trace fossils in a fine-grained succession, due to the abundance of fresh surfaces in cores available for evaluation. An ichnologic analysis was applied to cores from nine wells and one outcrop, which consisted in the description of ichnotaxa and other bioturbation metrics. This formation (ca. 150 m-thick) is composed of fine to medium mudstone, interbedded with coarse mudstone, tuff, limestone and bindstone, deposited in an oxygen-deficient, mixed carbonate–siliciclastic system. Indistinct bioturbation structures generate irregular-laminated (cryptobioturbation) and massive fabrics in fine to medium mudstone, associated with lower dysoxic to oxic conditions in soupy substrates. Discrete bioturbation structures were subdivided into nine ichnocoenoses. The *Coprulus oblongus*, *Alcyonidiopsis longobardiae*, *Teichichnus rectus*, and *Teichichnus rectus–Phycosiphon incertum* ichnocoenoses constitute oxygen-related ichnocoenoses (ORI) that occur in tuff, reflecting a gradient of lower dysoxic to oxic conditions in soft substrates. The *Palaeophycus heberti–Crininicaminus* isp., *Nereites* isp., equilibrichnia–fugichnia, and *Planolites* isp. ichnocoenoses are observed in heterolithic fine to coarse mudstone, and coarse mudstone, and are interpreted as produced under upper dysoxic to oxic conditions in softgrounds. The *Thalassinoides* isp. ichnocoenosis occurs in mudstone underlying tuff or intraclastic wackestone and represents oxic conditions in firmgrounds (*Glossifungites* ichnofacies). In previous paleoecologic studies, it has been argued that decreased benthic diversity could be produced by dysoxia or low substrate consistency. This analysis demonstrates the relationship between ORIs and cryptobioturbation, which helps to disentangle oxygen and substrate environmental controls and create a strong paleoecologic framework that can be applied to other ancient fine-grained depositional systems.

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Special Session 11.2. Trace fossils in sedimentological analysis: expanding their applicability in space and deep time

Oral presentation

Seeing through mud: effects of CT scanning on the ichnological interpretation of the Mira River estuary, Portugal

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Computed tomography (CT) is a relatively new technique in ichnological analysis, which allows for enhanced identification of individual trace fossils, their morphology, infill, tiering relationships, and preservation potential, thus providing better environmental interpretations. CT scanning is especially useful in homogenous sediments. This study was conducted on the tidal flat of the middle Mira River estuary – a mud-dominated, pristine coastal estuary of the Ria type and situated in the protected area of the Sudoeste Alentejano e Costa Vicentina Natural Park, Portugal. The estuary is mesotidal, with a mean tidal range of 2.4 m and tides propagating ~3–8 km inland. The salt wedge propagates up to 32 km upstream in summer. The fluvial inflow is seasonal and low. Two push cores were collected 2–3 m apart on a tidal flat located ~14 km upstream from the estuary entrance. The whole round cores were scanned using a GEOTEK MSCL-X CT scanner at IPMA Tavira. The obtained 3-D volume was cut vertically at 0°–180° and 270°–90° to produce core slices. The scanned cores were then cut longitudinally, logged, and photographed in daylight. Lithological and ichnological observations from visual core logging and CT core slices were compared. As a result, CT images provided a far more accurate description of cores and their environmental interpretation due to enhanced visibility of physical and biogenic sedimentary structures. For example, CT scans revealed that sediments appearing massive during visual core logging, were highly bioturbated (BI 4–6), and deposited under lower energy and stable environmental conditions during the low freshwater influx. In contrast, thin- to medium-laminated sediments were less bioturbated (BI 0–4) and deposited under conditions of enhanced physico-chemical stress during high fluvial discharge. Biological sedimentary structures like *Arenicolites, Skolithos, Planolites, Lockeia, Scalichnus,* siphonichnidal burrows, and rhizoliths were invisible in the fresh core. Their appearance on CT scans allowed for revealing complex tiering relationships and preferential preservation of deeper-tier *Scalichnus*-, *Planolites*-like, siphonichnidal, and fugichnia burrows in a typical modern estuarine tidal flat. Finally, CT scans provided evidence for a complex ichnofaunal community structure.

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Special Session 11.2. Trace fossils in sedimentological analysis: expanding their applicability in space and deep time

Oral presentation

Temporal constraints on the ichnofacies paradigm

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The great strength of ichnofacies as environmental indicators relies on the stability of individual ichnofacies through time. For the most part, this stability has been proven through a series of studies building on the original work of Seilacher from the 1950s and 60s, and refining the concept into our present understanding of the ichnofacies paradigm. However, something that is rarely taken into consideration is the uncertainty that surrounds ichnofacies at their point of inception – an ichnofacies cannot exist before tracemaking organisms have colonized the relevant sedimentary environment. As such, ichnofacies "originate" when a community of animals first colonizes a new habitat, and then gradually stabilize (or "evolve") as niches are created and occupied in different ways, until they reach their archetypal form. This means that in the early Palaeozoic, when many new ecological niches were colonized for the first time, there was far less stability. This is highly significant for the use of ichnofacies to distinguish early Palaeozoic sedimentary environments, as the ichnological signature of those environments may not have yet stabilized to match the signal of the archetypal ichnofacies. This issue is further compounded by secular changes in animal–substrate interactions through geologic time, such as increases in ichnodiversity, ichnodisparity, degree and extent of bioturbation, and complexity of tiering structure. Knowing when this occurred allows the ichnofacies paradigm to be employed more accurately by ichnologists, palaeontologists, and sedimentologists alike. In this presentation we will discuss the varying points of establishment of different ichnofacies, and how they "evolved" to reach their established form following their inception.

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Oral presentation

"*Kuphus tube*"? Or *Teredolites*? What does the Cenozoic carbonate intervals of the western Kutch (Kachchh) Basin of India suggest?

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The xylotreptic (wood-boring) and xylotrophic (wood-feeding) shipworms, *aka* the teredinids, are a group of bivalves occupying a range of brackish to open-marine benthic niches stratigraphically ranging from Jurassic to recent. Their peculiar bauplan consists of the soft tissues and a shell of highly reduced size. Although they are mostly woodborers, some teredinids also demonstrate rock-boring and ingesting behaviour in rare occurrences. The genus *Kuphus* belonging to the family of shipworms consists of four extinct (*K. arenarius*, *K. incrassatus*, *K. fistula*, and *K. melitensis*) and one extant (*K. polythalamius*) species. The genus is known from marine to brackish water settings, where they occur within the calcareous muddy stiff- to hardground preserved as vertical to inclined (also rarely horizontal) calcareous tubes, *aka Kuphus* tubes. The bivalve lives within the tube with an opening at the substrate–water interface. They follow two types of feeding strategy: (1) filter feeding by extending their long siphons from the opening and (2) deposit feeding while mechanically boring into the substrate. Thin surface annulations are present at the calcitic/aragonitic tube wall. The borings produced by the teredinids/shipworms are named as *Teredolites* isp. with two well-defined ichnospecies, *viz*., *T. clavatus* and *T. longissimus*. From the western Kutch basin of India, the solitary *Kuphus* tubes appear from the Eocene to Miocene carbonate deposits. The *in-situ* borings are almost vertical to sub-vertical in orientation having calcite wall linings and annulations, indicating episodic growth of boring by the trace maker. As these tubes does not act as the actual exoskeletal hard part of the animal, they cannot be considered true body fossil; rather, they testify the ethology of borers. Therefore, the "*Kuphus* tube" should be systematically described and classified as an ichnospecies of *Teredolites*. Hence, we propose the possibility of nomenclature and classification of a new ichnospecies, *T. solitarius*.

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Special Session 11.2. Trace fossils in sedimentological analysis: expanding their applicability in space and deep time

Oral presentation

Early Cambrian trace fossils in shallow-marine quartzites from Baltica and their implications for sedimentary stasis and anactualistic sedimentation

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The distribution of stratigraphic time in the rock record is controlled by the interplay between erosion, deposition, and stasis. Yet, the factors that determine how frequently a sedimentary system may have been in a state of deposition, erosion, or stasis have evolved through deep time: during the Cambrian, before the evolution of land plants with the capacity to stabilise terrestrial substrates, the influx of fluvially derived clastics to the marine realm would have been higher than it is today. This potentially impacted how time was archived within the strata and bedding planes that make up the Cambrian rock record, thus variably diluting or condensing palaeo-environmental data (e.g., trace fossils). To explore this notion, we here present new data from the clastic shelf deposits of the Lower Cambrian of southern Scandinavia, which records a stepwise transgression onto the Baltic shelf. We describe a new trace fossil assemblage from the Redalen Member (Lower Cambrian; Series 2) of the Mjøsa area, southern Norway. This new assemblage reflects a range of architectural styles, which are discussed in context of the depositional environment and the Cambrian diversification of early animals. We then compare the Redalen Member to other units of the Lower Cambrian of Baltica and use trace fossils, along with specific sedimentary structures, as a proxy for stasis in the depositional environment. In this way, we show how local sedimentary conditions control the abundance of bedding planes that reflect stasis at the sediment–water interface (i.e., 'true substrates') and suggest that ichnological motifs may be influenced by the anactualistic sediment supply to the shallow-marine realm. The further application of such an integrated sedimentological–ichnological approach is expected to improve our understanding of the distribution of stratigraphic time in the rock record of non-uniformitarian sedimentary systems.

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Poster presentation

Ichnology of a Lower Cretaceous Nova Scotian shelf-edge delta: the Missisauga Formation from the Sable Subbasin, offshore eastern Canada

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Shelf-edge deltaic sedimentary subenvironments developed during the Late Jurassic and the Early Cretaceous in the Sable subbasin, offshore Nova Scotia, experienced extremely depleted ichnological suites because of heightened physiochemical stressors on benthos. The subsurface Upper Missisauga Formation (UMF) is a Lower Cretaceous representation of this deltaic megasequence. Here, conventional UMF cores from the Glenelg and Alma fields have been sedimentologically and ichnologically examined. Hence, a depositional and ichnological model for the shelf-margin delta is constructed in a sequence-stratigraphic framework. The trace-fossil expression of the UMF on the northeastern side of the Glenelg field exhibits a sequence with bottom-current reworking by both tidal currents and underflows in its lower section of the upward-coarsening deltaic deposits. The dominance of the archetypal *Phycosiphon* Ichnofacies can be seen in its lower interval. The typical *Rosselia* Ichnofacies predominates over the subordinate *Phycosiphon* Ichnofacies in the deltaic upper succession that is impacted by waves and storms. The Glenelg field's deltaic ichnology confirms that the delta formed on the inner or, at most, medial shelf. The ichnological expression in the southwestern portion of the Glenelg field is exclusively a unique deep-marine mixed *Zoophycos–Nereites–Phycosiphon* ichnofacies. The Alma field region, in contrast, exhibits an unusual and widespread overprinting of a *Zoophycos* (–*Phycosiphon–Nereites*) suite over the pre-existing relict suites with medium to high ichno-abundance and exhibits variable tiering and taphonomic routes. The relict ichno-suites appear to belong to the archetypal *Skolithos*, *Rosselia*, and *Phycosiphon* ichnofacies that were intermittently preserved. Since the studied Alma region is the distal-most section at the paleo-shelf-slope break, autogenic delta abandonment and subsidence episodes might have led to development of the deeper *Zoophycos* suite that overprinted itself on all the palimpsest shallower suites previously belonging to the wave-influenced deltaic as well as other shallow-marine clastic wedges. At least at two intervals, the development of the *Glossifungites* Ichnofacies and their overlying bioclastic lag deposits mark rather more erosional allogenic flooding.

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Poster presentation

Nummipera saraswatii: A proposed armored ichnospecies in a transgressive nummulitic-bank setting from the early Eocene (Ypresian) Naredi Formation, Kutch (Kachchh) basin of India

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Bioclasts at the burrow wall ornated by infaunal producers and burrow orientation characterize the armored burrows. Ichnogenus *Nummipera*, with a sole type species *Nummipera eocenica*, is one of the distinguished ten known armored burrow ichnogenera. A unique preservation of *Nummipera* has been documented in the *Assilina* packstone of early Eocene (Ypresian) Naredi Formation from the Kutch basin, India. These armored burrows are oriented horizontal with respect to the bedding plane in contrast to vertical *N. eocenica*. A new ichnospecies *N. saraswatii* is proposed here with the following ichnotaxobases: (1) Horizontal to gently inclined (< 20°), tubular, intermittently vertically flattened causing circular to elliptical cross-sections with two distinct diameter classes, *viz.*, 1–1.3 cm (narrower) and 2–3 cm (wider), straight to feebly curved; (2) Walls lined with mostly unbroken megalospheric (A-form) tests of *Assilina* aligned at 0° to 30° to the burrow axis both towards and away from the lumen. The narrower variety is ornated with well-sorted *Assilina* and has smooth inner wall. The wider variety demonstrates poorer sorting of ornating tests and rougher inner wall; (3) Lumen either (a) is filled with homogeneous fine-grained host material in the narrower burrows or (b) shows annulation originating from alternate coarse- and fine-grained sandy active backfill in wider burrows; (4) Unbranched; (5) No spreiten. Crustaceans and worms can be envisaged as probable producers respectively for the wider and narrower subspecies based on the distinctive burrow morphology and ethological affinity. The *Nummipera–Cylindrichnus* ichnofabric (NCi) of the 30 cm-thick trough-cross-stratified *Assilina* packstone shows association of shallow-tiered *Nummipera saraswatii* with the deep-tiered *Cylindrichnus concentricus*. The NCi with low ichnodiversity and intense bioturbation (BI 5) depicts a depauperate *Cruziana* Ichnofacies deposited in a parautochthonos biofabric of the shelfal bank setting and corresponds to the 'maximum flooding zone' during the Early Eocene Climatic Optimum (EECO). The NCi in *Assilina* packstone demarcates an overall deepening and transition of the restricted eutrophic condition of the basin into an open oligotrophic shelfal bank.

Theme 12. Stratigraphic markers and archives

Special Session 12.1. Understanding major paleoenvironmental and paleontological crises during the Mesozoic by exploring shallow water carbonates geological archives

Oral presentation

Sedimentary mercury as a proxy for volcanism in the Tethyan carbonate platforms during OAE-2

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The Cenomanian–Turonian Oceanic Anoxic Event 2 (OAE-2) was one of the major perturbations recorded in the global carbon cycle during the Cretaceous, associated with a worldwide deposition of organic-carbon rich sediments (black shales) in the oceanic basins. Numerous studies have linked large-scale volcanism, associated with large igneous province (LIPs) emplacement, to OAEs. Volcanoes are a primary source of mercury (Hg) to the global oceanic–atmospheric system. Accordingly, analyses of sedimentary mercury anomalies recorded in carbonate platform could be used as a chemostratigraphic proxy for large volcanic eruptions during intervals of severe paleoclimatic changes including OAEs. In addition, the use of stable isotope systematics of Hg are useful to clarify the origin of Hg sedimentary spikes. Up to date, the Hg record throughout the OAE-2 has been derived from deep water carbonate successions. Preliminary data have been used to corroborate the hypotheses of a coincidence between volcanic activity associated to LIPs, and the severe environmental perturbation linked to the OAE-2. On the contrary, the shallow-water carbonate counterparts have been less investigated for their Hg content making the understanding of the Hg record during the OAE-2 largely incomplete. Here, we present new Hg concentration and Hg isotope data used as proxies for increased volcanic inputs, together with sedimentological and geochemical data, from well exposed shallow water carbonate series cropping out in the Tethyan realm, across the OAE-2. Biostratigraphy and carbon-isotope stratigraphy have been used to establish a precise stratigraphic framework and for high-resolution correlations. Results suggest that during the OAE-2, all platforms underwent important Hg fluctuations which are well correlated across the study locations. However stable isotope systematics of Hg suggest that not all Hg spikes could be directly related to volcanism. Finally the high resolution stratigraphic framework established in this study could allow correlating the shallow water Hg record to that of the deep water carbonate deposits which is an important step to understand if and how volcanic activity have modulated the OAE-2 at global scale.

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Oral presentation

Potential episodes of ocean acidification during Oceanic Anoxic Event 2

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Oceanic Anoxic Events (OAEs) are episodes of major paleoceanographic and paleoclimatic changes associated to Carbon cycle perturbations registered both on land and in marine strata. Among the OAEs the so-called Oceanic Anoxic Event 2 (OAE-2), spanning the Cenomanian–Turonian boundary (around 94 Ma) is one of the most severe. Several lines of evidence suggest that this event was triggered by an increase of atmospheric pCO_2 caused by massive gas emissions from volcanic sources.The sedimentary record of the OAE-2 in marine carbonate successions worldwide, is characterized by a positive carbon isotope excursion (CIE) of up to 5 per mil. In the most complete records, the OAE-2 CIE shows a complex pattern consisting of a first buildup, a trough, a second buildup and a plateau with spikes. The "trough" coincides with a short interval of cooling known as Plenus Cold Event defined by a positive $\delta^{18}O$ excursion and it is tentatively interpreted as the expression of CO_2 drawdown.

One major effect of the pulses of volcanic degassing during OAE-2 would have been increase of dissolved CO_2 in the oceans which, if rapid enough, could have resulted in ocean acidification. Limited studies based on morphometric analyses of nannoplankton species and abundance of planktonic foraminifera suggest that short phases of ocean acidification may have occurred during OAE-2. However, up to date, there is no definitive proof supporting this hypothesis, unlike other OAEs for which geochemical and paleontological data have provided more solid evidence of ocean acidification. Moreover, at present there are no studies testing the hypothesis of ocean acidification during OAE-2 in carbonate platforms, whose massive biocalcifiers would have been particularly sensitive to a decrease in carbonate saturation.

In this study we present new data from two successions of shallow-water carbonates belonging to the Apennine Carbonate Platform (Southern Italy) and Adriatic Carbonate Platform (North-East Italy). We complemented the available carbon-isotope data with high-resolution facies analyses coupled with laser $\delta^{11}B$ measures on well-preserved bivalve shells. Preliminary data show a negative inflection in $\delta^{11}B$ associated to the negative CIE of the Plenus Cold Event. We discuss possible scenarios for these patterns, including a short-lived episode of ocean acidification.

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Oral presentation

Origin and preservation of cyclic successions in different environments of the Dachstein platform system around the Triassic–Jurassic boundary

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The Triassic–Jurassic boundary and the effects of the end-Triassic events are recorded in different environments in the Transdanubian Range in Hungary. The Csővár section represents a continuous succession across the boundary, deposited in an intraplatform basin located in the external belt of the Dachstein carbonate platform system, whereas the Kálvária Hill section at Tata represents the internal part of the platform system that is characterized by a hiatus at the boundary.

We performed cyclostratigraphic and astrochronologic analyses on both of these previously well-studied carbonate successions. In addition to the identification of the Milankovitch-cycles and the astrochronological age model, the results gave insights into the depositional systems by combining data from earlier studies with the coherence and phase analyses.

In the Csővár section we proved that the previously identified 3rd and 4th–5th order sequences and smaller-scale pelagite–calciturbidite cycles can be linked to orbital forcing. The 4th–5th order sequences are in good agreement with the long eccentricity cycles up to the level of the Initial Carbon Isotope Excursion. Upsection this relationship becomes blurred, probably due to the disturbances by the end-Triassic events. Based on geochemical, sequence stratigraphical and cyclostratigraphical data, a complex dynamic environmental model was developed for this section. This model suggests that the main driver of the observed cyclicity was the opposite response of the detrital input and the carbonate accumulation in the basin to changes driven by aquifer- and limno-eustasy and the “megamonsoon” system that characterized the peri-Tethyan realm during the existence of Pangea.

In the Kálvária Hill section, our astrochronological age model suggests that the record of a few hundreds of thousands of years is missing at the base of the Jurassic. This gap can be attributed to the end-Triassic crises and the subsequent ″unreefing″ leading to the demise of large parts of the carbonate platform. The missing c. 200–300 thousand years may represent the time needed for the recovery of carbonate production and accumulation. A similar but more conservative environmental model was established for this section, also emphasizing the role of the “megamonsoon” system.

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Poster presentation

Evolution of the large benthic foraminifera assemblages during the Cenomanian–Turonian OAE2 from the Mexican Guerrero–Morelos carbonate platform

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Major faunal and flora extinctions occurred during the Cenomanian–Turonian Oceanic Anoxic Event (OAE). Only few carbonate platforms survived during this crisis like the Guerrero–Morelos carbonate platform (SW Mexico). The $\delta^{13}C$ curves of the studied sections exhibit the typical OAE2 features including a large positive excursion, which allows a better understanding of large benthic foraminifera distribution during this event and their biotic response to paleoenvironmental changes. The results exhibit several key-points of this evolution: 1 – Before the carbon isotopic excursion, which characterises the OAE2, a well-developed carbonate platform develops in a shallow tropical sea environment with rudists and large benthic foraminifera. The mineralogy of shells and skeletons shows a great diversity from aragonite to calcite, and from low to high magnesium calcite; 2 – At the onset of $\delta^{13}C$ excursion, a remarkable karstified surface corresponds to an emersion (SB Ce5). 3 – During the OAE2 interval, the establishment of major oxygen crisis is highlighted by cyanobacterial deposits in regular laminations made in low magnesium calcite; 4 – Towards the top, an episodic reestablishment in more oxic conditions occurs with the return of benthic foraminifera like miliolids; 5 – Just after the Cenomanian–Turonian boundary, a re-oxygenation is accompanied by the reinstallation of open-marine fauna with calcite or low magnesium calcite test. 6 – During the Lower Turonian, the platform is trying to reinstall itself for the last time before a significant sea-level drop associated with karstic episode, which are followed finally by major transgression which drowned it definitively. The mineralogical composition evolution of shell organisms and calcareous skeletons shows that organisms with an aragonitic skeleton or with magnesium calcite disappear in favor to calcitic or low magnesium calcite organisms during the OAE2 interval. After the OAE2, if organisms living in well oxygenated environments come back, it is only after a certain time that the return of aragonitic organisms or to very magnesium calcite is observed. These data support the hypothesis of the possibility of an oceanic acidification just at the onset of the OAE2 episode which have led to faunal and flora composition changes.

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Poster presentation

Reconstructing redox and hydrographic dynamics during the Early Toarcian (Early Jurassic): new insights from Mo/TOC covariation

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During the early Toarcian (Early Jurassic), intensification of marine anoxia led to widespread deposition of black shales. This event, known as the Toarcian Oceanic Anoxic event (T-OAE), caused the extinction of several marine taxa and perturbations in geochemical cycles. It has been linked to massive inputs of volcanogenic CO_2 from the Karoo–Ferrar Large Igneous Province, causing a large temperature rise and global transgression. In this work, we address one of the main debates concerning the T-OAE, which is the cause of the exceptionally low content of molybdenum (Mo) in black shales of that age. To date, two main models have been proposed: the "global model", which proposes a generalized worldwide Mo drawdown in the Toarcian ocean; and the "local model", which argues for hydrographic restriction in limited basinal areas as the cause of Mo impoverishment. In this context, we have generated new sedimentological, Mo and total organic carbon (TOC) data from two sections (Lastres and Rodiles) in the Asturian Basin (northern Iberian Paleomargin), which are integrated with and compared to a global dataset for ~25 sections representing all major ocean basins. The aim of this study has been to evaluate the role of hydrographic restriction (i.e., limitation of bottom-water renewal) and euxinia during the T-OAE and their relationship to Mo drawdown. Several black shale deposits exhibit exceptionally high Mo and TOC contents (21–42 ppm Mo, 12–18% TOC), along with extremely low mMo/TOC (0.32–0.65), indicating euxinic bottom- and porewaters and strong hydrographic restriction in several basins among the Northwestern (epicontinental intrashelf troughs like the Cleveland and Paris basins) and Eastern Tethys (barrier–lagoon setting in the Qiangtang Basin). On the contrary, basins in the Southwestern Tethys, Iberian Paleomargin (including Asturian Basin) and Panthalassa were pelagic/hemipelagic and ramp carbonates with absent or intermittent euxinic porewaters, thus exhibit lower Mo and TOC values (i.e., unrestricted). Notably, comparison of Toarcian basins with modern and Mesozoic analogues indicates markedly lower values of Mo in the former. Thus, our results indicate a general aqueous Mo drawdown in global seawater during the T-OAE, with local hydrographic restriction modulating the final expression of the event.

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Poster presentation

The transition early–late Sinemurian crisis: environmental perturbations in shallow carbonate platform of Mallorca (western Tethys)

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The early Jurassic was a time characterized by major paleogeographic changes related to the breakup of Pangea, which was accompanied by several climatic and environmental crises. Well known are the Sinemurian–Pliensbachian Boundary Event, the late Pliensbachian cooling or the early Toarcian Oceanic Anoxic Event. Other climatic and environmental crisis, as the early–late Sinemurian Event (around *Turneri* to *Oxynotum* ammonite Zones), are still less documented but had an effect in the carbonate depositional systems of many Tethyan areas. In the shallow-water carbonate platform of Mallorca (Es Barraca Fm) this event is reflected in a sharp change in facies and geometry. The platform evolved from a nearly flat peritidal–shallow subtidal platform, characterized by Bahamian-type carbonates including stromatolites, fenestral-restricted mudstones, peloidal-oolitic grainstones and algal-foraminiferal wackestones; to an open platform made of mud-wackestones with molluscs and benthic foraminifera, bioturbated lime mudstones and spiculitic facies. This facies change, occurred around the early–late Sinemurian boundary (according to benthic foraminifera biozonation), and represents a rapid flooding of the peritidal platform. It resulted in the demise of the Bahamian-type carbonate factory, which was replaced by more open-marine muddy subtidal substrates with higher water turbidity, promoting the proliferation of suspensivorous heterotrophic species. It was coincident with the onset of differential subsidence in the studied area. The changes in both, sedimentary facies and platform style of Mallorca, are accompanied by excursions in the $\delta^{13}C$ composition of marine carbonates identified in several platforms of the Tethyan realm. Thus, the observed changes in Mallorca can be interpreted as the impact in the neritic environment of an ecological crisis associated to global perturbations of the carbon cycle and a possible climate event, changing toward warmer and more humid conditions. After this event, during the late Sinemurian, despite differential subsidence, the recovery of the Bahamian-type carbonate factory occurred in the shallow platform environments of Mallorca with identical facies to those previous to the event.

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Special Session 12.2. The sedimentary role of calcareous green algae, from Paleozoic to modern

Oral presentation

Spatial and temporal distribution of Messinian *Halimeda* beds in the Sierra de Gádor (Almería, SE Spain)

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Coral reefs and associated shallow-water deposits fringed the antecedent relief of the Sierra de Gádor (Almería, SE Spain) in the early Messinian (Late Miocene). At that time, this paleorelief was a small peninsula connected to the Iberian mainland on its west-northwest side and surrounded by the Alpujarra Corridor, the Almería–Níjar and the Poniente basins, which were marginal basins of the Mediterranean Sea. *Halimeda*-rich carbonates (*Halimeda* beds) are common among the Messinian reef-related deposits around Sierra de Gádor. They generally consist of floatstones to rudstones of *Halimeda* segments in a muddy carbonate matrix with secondary bioclasts of coralline red algae, corals, bivalves, serpulids, echinoids, and benthic foraminifers. The beds are structureless, the orientation of *Halimeda* segments is mostly random and the degree of bioclast fragmentation is generally low. Aragonite in all components was dissolved and molds were partially or totally filled by calcite cements. The beds are decimeters to few meters thick and tens to hundreds of meters in lateral extension in the best exposures. They accumulated in slopes of *Porites* reefs downslope of coral breccias and both basinward and shoreward of coralline algal floatstones to rudstones. The highest development of *Halimeda* beds took place in high relative sea levels during aggradation and progradation of the Messinian reef deposits. The spatial distribution of *Halimeda* beds around the Sierra de Gádor is uneven. The highest concentrations accumulated at the eastern point of the peninsula, where the sediment influx was negligible. By contrast, *Halimeda* growth was reduced or absent in areas with higher terrigenous sediment inflow.

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Special Session 12.2. The sedimentary role of calcareous green algae, from Paleozoic to modern

Oral presentation

Boueina, important carbonate producer from the Lower Cretaceous limestones of the Carpatho–Balkan region

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At the end of the nineteen century, Franz Toula described from sedimentary deposits considered to belong to the Neocomian a fossil whose systematic position was unknown and which he named *Boueina hochstetteri*. Some years later, Steinmann noted the similarity of the internal structure of this fossil with that of the modern *Halimeda* and considered it to belong to Codiaceae green algae. Steinmann considered that *Boueina* differs from *Halimeda* by the lack of segmetation and, probably, of branching. The alga was later reassigned to segmented Udoteaceae or Halimedaceae by different authors. De Castro et al. (2008) demonstrated that *Boueina* is really not segmented, but shows rare branching. Recently rediscovered (Bucur et al., 2018), the type outcrop of *Boueina hochstetteri* comprises a 1.5–2 m calcareous bank in which the *Boueina* thalli are predominant. An estimated quantitative calculation, carried out on the basis of some thin sections, revealed a content of *Boueina* thalli between 60 and 80% of the rock volume. This certifies the fact that *Boueina* was, during the Lower Cretaceous, a calcium carbonate producer similar/equivalent to modern *Halimeda*. Important accumulations of *Boueina hochstetteri* thalli have been identified in the Lower Cretaceous of the entire distribution area of the Getic domain, from southwestern Romania (Reşiţa–Moldova Nouă zone) to Eastern Serbia (Carpatho–Balkanides). Their sedimentary role in the formation of the Barremian–Aptian carbonate rocks of the Carpatho–Balkan area will be emphasized.

References

Bucur, I.I., Sudar, M., Jovanović, D., Pleş, G., Polavder, S. (2018): Rediscovery of the type locality of the Udoteacean alga Boueina hochstetteri Toula, 1884, in the Lower Cretaceous of Serbia. Carnets de Géologie, 18(4): 123–137.

De Castro, P., Cimmino, M.G., Barattolo, F. (2008): On some infrageneric rank-changes within the Mesozoic Boueina (Chlorophyta, Caulerpales). Atti Academia Pontaniana, Napoli, N.S., LVII: 175–182.

Theme 12. Stratigraphic markers and archives

Special Session 12.2. The sedimentary role of calcareous green algae, from Paleozoic to modern

Keynote lecture

Have green algae been major sediment contributors since their Early Palaeozoic origin?

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Fine-grained limestones are widespread throughout the Palaeozoic, and are especially common in low (palaeo-)latitudes. Scanning electron microscopy studies of such rocks have shown that the precursor muds often consisted to a considerable extent of aragonite (mainly aragonite needles). In most cases it is unclear whether this aragonite was produced by precipitation from seawater (whitings) or by the decay of aragonitic skeletons, especially green algae. In modern shallow-marine, low-latitude environments a large part of the aragonitic mud results from the decay of green algae such as *Halimeda* or *Penicillus*, whose skeletons consist of aragonite needles. This, however, is difficult to prove even in very young rocks because the aragonite needles have been completely transformed by diagenesis, and fragments of green algae are quite rare in most thin sections due to their susceptibility to diagenesis. In pre-Pennsylvanian rocks it is even worse. Whereas primarily aragonitic algae such as dasycladaleans and phylloid algae were relatively common in Late Carboniferous (Pennsylvanian) and Permian times, green algae are rare in older rocks. This could mean that in the early and middle Palaeozoic most of the aragonitic mud would have been due to whitings, but this contradicts the view that sea-water precipitates in this time period were primarily calcitic ("calcite sea"). Alternatively, it might be possible that green algae produced a lot of aragonite mud but hardly left any traces in the fossil record. In this talk, microfacies evidence from modern and ancient samples will be presented that indicates that decaying green algae contributed significantly to carbonate mud, even in pre-Pennsylvanian times.

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Oral presentation

Project HALO: unravelling the origins, function, and fate of *Halimeda* bioherms in the Great Barrier Reef

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Over 6000 km^2 of the northern GBR (Great Barrier Reef) shelf is marked with striking, complex 'donut-shaped' bioherms composed of *Halimeda*-rich sediment and living *Halimeda* meadows atop. A lack of systematic cross-shelf sampling available to early studies from the 1980's, as well as the recent discovery of the bioherms true 3D shapes, means that the formation and evolution of these calcareous algae deposits and the fundamental processes that control their distribution and development must be reassessed. In August and September 2022, a multidisciplinary team of scientists embarked on a 26-day voyage on the Australian RV *Investigator* to map and sample these bioherms in unprecedented detail, with particular emphasis on surface and subsurface geophysical data acquisition and collection of new precisely targeted vibrocores up to 6 m long. Sub-meter resolution multibeam echosounder bathymetry data reveals the spectacular bioherm shapes and patterns not previously visible even with state-of-the-art LiDAR. The internal structure of the bioherms was sampled by recovering targeted cores and rock dredge samples to correlate with closely spaced lines of sub-bottom profiles. Preliminary observations include possible paleomangrove muds, cemented grainstones, and fossil reef deposits. Analysis of the water column through diurnal and tidal cycles reveals a relationship to seafloor morphology and tidally driven currents. Incubation experiments of multicore samples of the sediment/water interface indicate significant nutrient cycling between the sediments and overlying water column. Integration of oceanographic data, sedimentary facies, geochronology, and marine geophysical data will allow the team to reconstruct the 4D development of the bioherms through the Holocene. Guided by the new bathymetry, biota was sampled using systematic drop camera imagery and sediment grabs guided by the new seafloor mapping which will add to recent research that has shown that the bioherms are hot spots of biodiversity relative to adjacent inter-reef areas. Project HALO (Halimeda Bioherm Origins, Function and Fate) will provide insights into these unique seafloor features, shed light on biogeochemical nutrient cycling and diagenesis, and as modern habitats amid one of Earth's most critical but vulnerable ecosystems.

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Special Session 12.2. The sedimentary role of calcareous green algae, from Paleozoic to modern

Oral presentation

A new type of mesophotic *Halimeda* bioherms (Queensland Plateau, NE Australia)

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Using high-resolution hydroacoustic data, direct seafloor observations, in-situ temperature and salinity measurements, as well as discrete sediment samples recovered during RV SONNE Expedition SO292 to the Queensland Plateau, we present a new type of *Halimeda* mound, based on its morphology, surficial facies distribution and internal structure. The *Halimeda* bioherms are conical with a diameter of up to 500 m and a top located in water depths of 50 mbsl in average. Each mound elevates 3–10 m above the local baseline. The mound flanks have an inclination between 2° to 5°, with the slopes not being symmetrical. The central part of some mounds is occupied by a small pinnacle formed by corals. With respect to their surficial distribution of sediment and organisms, the mounds show four facies belts, which are from deepest to shallowest: 1) *Halimeda* rudstone, 2) *Halimeda* rudstone with living plants, 3) *Halimeda* rudstone with coral and coralline red-algae debris, and 4) Coralgal boundstone. Main components of the rudstone are *Halimeda* plates (more than 85% in average), followed by coralline red algae, and common to few large benthic foraminifera (especially *Sorites*). The amount of living *Halimeda* plants increases from the base of the mound up to the area occupied by coralgal debris. The coralgal boundstone is located in the uppermost part of the mound, that is the center pinnacle, and is dominated by the presence of the platy corals *Pachyseris speciosa* and secondarily by *Podabacia* crustacea. The internal structure of the mounds as imaged by PARASOUND sediment echosounder data consists of convex-up faint lamination with coarser layers fading out from the core of the mound toward the flanks. Architecture and facies composition of these mounds is interpreted to reflect the interplay of mesophotic carbonate production by corals and *Halimeda*, and the dismantling and remobilization of the pinnacle area by intense bottom currents triggered by severe storms.

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Special Session 12.2. The sedimentary role of calcareous green algae, from Paleozoic to modern

Oral presentation

Morphometric analysis of *Halimeda* bioherms on the northern Great Barrier Reef using high-resolution bathymetry dataset

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Halimeda accumulations form some of the largest connected biogenic structures in the Great Barrier Reef covering >6000 km^2 of the continental shelf which is larger than the adjacent coral reefs at the same latitude. Previous studies have shown that the shapes and patterns of these accumulations are complex with remotely sensed bathymetry data revealing honeycomb-like surfaces with three different morphological sub-types (reticulate, annulate, undulate) rather than linear parallel dunes as previously thought. This study presents new data from the 2022 RV Investigator voyage V07 *Halimeda* bioherms: Origins, function and fate in the northern Great Barrier Reef (HALO). Data will be presented from 3 inter-reef sites (Ribbon Reef, Cormorant Reef and Tijou Reef) across the shelf spread over 2.5 degrees of latitude in the northern Great Barrier Reef margin. The highest spatial resolution multibeam bathymetry dataset available for the study area (sub-metre horizontal resolution) was analysed for surface gradients (slope, aspect, curvature), bathymetric position index and quantified terrain complexity or surface heterogeneity using 3D Analyst Toolbox and Benthic Terrain Modeler (ArcGIS Pro). The bathymetry interrogation is complemented by backscatter intensity, targeted seafloor images and surface sediment samples that show a complex connected bioherm structure. The increased resolution from our investigation reveals high complexity with variable seafloor characters within and across morphotypes.

Theme 12. Stratigraphic markers and archives

Special Session 12.2. The sedimentary role of calcareous green algae, from Paleozoic to modern

Poster presentation

Recent insights on green-algal carbonate systems informed by Holocene *Halimeda* bioherms in the Great Barrier Reef, Australia

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The *Halimeda* bioherms of Australia's Great Barrier Reef (GBR) are a spectacular living example of an actively accumulating calcareous green algae carbonate factory, with analogous accumulations well-recognised in the fossil record. For example, the *Halimeda* 'segment reefs' of the Sorbas Basin, Spain, and Salento Peninsula, Italy, represent well-preserved Miocene outcrops. Additionally, *Halimeda*-rich stratigraphic sections in the Atlas Mountains, Morocco, are known from as far back as the Paleocene. *Halimeda* algae and the GBR *Halimeda* bioherms have long been considered by some authors to represent a modern analogue for the comparable but taxonomically unrelated phylloid algal mounds of the late Paleozoic. These systems appear to have some commonality in their depositional and physiographic setting, with proximity to the seaward margins of continental shelf edge/slopes or isolated platforms, with coralgal reef facies associations. The sedimentary importance of *Halimeda* as a 'reef' building organism was not fully appreciated until marine echosounder and seismic investigations advanced the discovery of Holocene *Halimeda* mounds/bioherms in the late 1970s and 80s. *Halimeda* bioherms have since been discovered in the Great Barrier Reef, Java Sea, SW Caribbean, Timor Sea, and off western India. More recent research facilitated by high-resolution bathymetric LiDAR has revealed surprising new insights into the geomorphology of the GBR *Halimeda* bioherms, stimulating renewed scientific interest in this algal-dominated carbonate system. This presentation integrates recently published work encompassing the evolution of the GBR bioherms in response to the Holocene marine transgression, informed by a new radiocarbon age/depth dataset and vertical facies transitions; their spatial distribution, geomorphology and morphometrics; the role of upwelling in nutrient delivery through analysis of skeletal nitrogen isotopes; and their ecological importance in supporting benthic biodiversity. We seek to stimulate renewed discussion on *Halimeda* bioherms across the modern and fossil research communities and share insights that may be relevant to those working on paleo-algal systems.

Theme 12. Stratigraphic markers and archives

Special Session 12.3. The stratigraphic record of paleoenvironmental variation in epeiric basins

Oral presentation

Euxinic expansion in epeiric seas of North America during the Late Devonian Hangenberg Event

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The Late Devonian marks a major transition in Earth history when the expansion of rooted land plants led to a cascade of effects, including enhanced terrestrial weathering and oceanic nutrient delivery, expanded anoxia in epeiric seas, organic carbon burial that drove a decline in pCO_2 and a rise in pO_2, and the transition to the Late Paleozoic Ice Age. The Late Devonian was also characterized by a series of major extinction events, the two largest of which were the Kellwasser Event near the F–F boundary and the Hangenberg Event just prior to the D–C boundary. The Hangenberg Event witnessed widespread devastation of marine ecosystems and has been linked variably to volcanism, climate change, and marine anoxia. Although global redox proxies clearly indicate expanded ocean anoxia, documenting the 4D expansion of anoxia and/or euxinia on the scale of individual basins is necessary to tie ocean redox directly to biodiversity loss. Here, we present paleoredox (Fe speciation, trace metal, N and S isotope) data for two basins that span the Hangenberg Event in North America – six cores through the Cleveland Shale (Appalachian Basin) and two cores through the Lower Bakken Shale (Williston Basin). In the Cleveland Shale, the pre-Hangenberg interval was characterized by a pronounced redox gradient from oxic conditions proximal to the Catskill Delta, to ferruginous conditions in the central basin trough, to euxinic conditions along the Cumberland Sill. During the Hangenberg Event, however, euxinic conditions expanded to the site of all six cores, and V and Zn hyper-enrichments indicate abundant H_2S in the photic zone. A similar scenario is recorded in the Williston Basin where euxinia reached its maximum areal extent coincident with the Hangenberg Event. In addition to these eight cores investigated for a suite of mass spectrometry-based proxies, our interpretation is aided by a compilation of XRF trace metal data from 90 cores (~11,000 data points) across the entire Williston Basin. This dataset allows for a 4D reconstruction of basin redox, which clearly shows euxinic waters shoaling and onlapping the basin margins during the Hangenberg Event. Ultimately, comprehensive paleoredox reconstruction of the Appalachian and Williston seaways strongly supports H_2S toxicity as a major driver of Late Devonian biotic change.

Theme 12. Stratigraphic markers and archives

Special Session 12.3. The stratigraphic record of paleoenvironmental variation in epeiric basins

Oral presentation

Sedimentary record and paleoenvironmental reconstruction of a Middle–Late Miocene marine to lacustrine succession: Pannonian Basin, southern Hungary

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During Middle to Late Miocene the central Pannonian Basin evolved from a marine (i.e. Paratethys) to a brackish lacustrine environment due to disconnection with the Mediterranean Sea and Indo–Pacific Ocean. The sedimentary record of such a transition is still poorly documented as consequence of studies mostly focusing on incomplete outcrops. To address this gap, here we present new data from a well drilled by MOL Group in 2019 in southern Hungary that retrieved approx. a 50-m long core of a Middle to Late Miocene succession. The core was analyzed with a high-resolution integrated analytical approach including sedimentological, biostratigraphical, compositional, and geochemical analyses. The study interval was divided into units A, B, and C from bottom to top. Unit A consists of Middle Miocene cross-laminated silty sandstone with conglomerate intercalation. It contains marine biotas (e.g. miliolids, rotaliids, red algae, dinoflagellate cysts) and it is TOC lean. The overlying Unit B consists of 10-m thick organic silty marl to calcareous marl with intercalation of debrites and ash beds. Microfossils are mostly marine (*Elphidium* sp., ostracods, calcareous nannoplankton, prasinophycean algae) and TOC is up to 4 wt%. In addition, Unit B is characterized by a distinct peak of molybdenum concentration, high gammacerane, and low hopane/sterane ratio. The topmost Unit C consists of marl/limestone alternation and TOC is up to 2 wt%. Microfossils show low diversification consisting mostly of ostracods, calcareous nannoplankton, and dinocysts with the latter pointing to Late Miocene (Pannonian s. l.) age. In this unit, both molybdenum concentration and gammacerane are low whereas hopane/sterane ratio is high. Units A to C represent a transgressive succession with fan-delta deposits at its base (Unit A), overlain by distal organic silty marl (Unit B) and calcareous marl (Unit C). Moreover, it records a paleoenvironmental transition from marine oxic (Unit A) to marine dysoxic with periodic stratified water column (Unit B) to brackish lacustrine oxic/suboxic (Unit C). Additional palynological analysis as well as nannoplankton analysis will be performed next, aiming to increase the age resolution of such a marine to lacustrine transition.

Theme 12. Stratigraphic markers and archives

Special Session 12.3. The stratigraphic record of paleoenvironmental variation in epeiric basins

Oral presentation

Beyond evaporites: hypersaline conditions in ancient epeiric seas

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Salinity is one of the key parameters for establishing the chemical and physical properties of watermasses. It is well known that in modern aquatic environments, salinity is the final product of a complex interaction of rates of evaporation and precipitation, freshwater runoff, geographical location, and ultimately, the degree of connection with the open ocean. Epeiric seas represent much of the "marine" record preserved in the geological past, although modern analogues are less common, and the scarce modern pseudo-analogues exhibit salinity values that range from almost freshwater to hypersaline conditions. However, it is commonly assumed that epeiric seas presented normal marine conditions in the geologic past unless the presence of evaporites indicates hypersalinity. In this contribution, we demonstrate the existence of hypersaline conditions in two interior basins of the Late Devonian North American Seaway (Illinois and Williston basins). Paleosalinity proxies (B/Ga, Sr/Ba, and S/TOC) from the New Albany Shale (Illinois Basin, ~34° S paleolatitude) record a reduction in salinity from hypersaline to marine conditions in two cores across the Frasnian–Famennian boundary. In addition, Mo/TOC slopes rise from 2.6–4.1 in the Frasnian to 10.7–12.8 during the Famennian, indicating a switch from a high to moderate degree of basin restriction. This suggests that during the Frasnian, the Illinois Basin was more restricted, and potentially more isolated, and that led to hypersalinity due to high evaporation rates. On the contrary, during the Famennian a sea-level rise connected the basin with the rest of the epeiric sea, allowing the input of marine water that reduced the salinity. Increased terrestrial runoff during the Famennian related to the expansion of land plants could have also influenced the lowering of watermass salinity. In the Williston Basin, however, Mo/TOC slopes for the Famennian suggest a low degree of restriction but still hypersaline conditions according to paleosalinity proxies, probably related to its closer proximity to the paleoequator (~19° S) and more arid local climate conditions. This case of study demonstrates the importance of measuring salinity in ancient epeiric seas due to its influence in the physico-chemical properties of their watermasses.

Theme 12. Stratigraphic markers and archives

Special Session 12.3. The stratigraphic record of paleoenvironmental variation in epeiric basins

Oral presentation

New insight into the North Central Paratethys Sea development

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The remnants of the North Central Paratethys Sea are dispersed today in the territory of Slovakia, Hungary, Austria and Ukraine. This area has a long history of research, but many questions still linger. This study aims to fill in the missing pieces by assigning depositional environment and stratigraphy to selected sites and events. To acquire this aim, sedimentology, biostratigraphy, $^{40}Ar/^{39}Ar$ dating and interpretation of geo-seismic lines was applied. Reliable stratigraphic constraints in the Paratethys can be applied up from the time when the area suffered an eruption that resulted in 10s of m thick and 10s of km wide ash fall deposits, the "Lower Rhyolite tuff" (Lukács et al., 2018). New sites with ages of, e.g., 17.28±0.06 Ma are revealed in the Novohrad–Nógrád Basin. The converging Eurasia–Africa plate-boundary sets in motion a 50° CCW rotation (Lukács et al., 2018). This event of the Karpatian age restricts seaways in the Vienna Basin (VB) and Transcarpathian Basin (TB) and give rise to muddy strata with anhydrite nodules. Inversion and erosion set in. The next dated ash fall of lower Badenian age is confirmed e.g., by the "Kuchyňa tuff" in VB to 15.23±0.04 Ma "Upper Rhyolite tuff". Further 30° CCW rotation event takes place. The Badenian flooding follows, and is confirmed by the FOD of Orbulina suturalis and by the NN5 Nanno-Zone. Heterolitic muds in the juvenile Danube Basin (DB) point to the mid-outer shelf setting. Volcanism changes to predominantly andesite in composition and its onset is represented, e.g., by a newly presented age from the buried Kráľová volcanic field (in DB) dated to 14.09±0.15 Ma. Later strata from the DB yield ages of 13.83±0.11; 13.75±0.14 Ma and document a major sea-level fall, also reflected in other basins (e.g. TC) by salt-clays and evaporite layers termed "Salinity Crisis". All basins are subject to two more transgressive–regressive cycles (u. Badenian and Sarmatian). Alterations of algal limestone's with sands and mud show dynamic transitions between carbonate and clastic systems.

Reference

Lukács, et al. (2018): Early to Mid-Miocene syn extensional massive silicic volcanism in the Pannonian Basin (East–Central Europe). Earth-Science Reviews, 179, 1–19. DOI: https://doi.org/10.1016/j.earscirev.2018.02.005

Theme 12. Stratigraphic markers and archives

Special Session 12.3. The stratigraphic record of paleoenvironmental variation in epeiric basins

Oral presentation

Large-scale reconstruction of the Early Cretaceous Neuquen Sea (SW Gondwana): unravelling key parameters for characterization and classification of epeiric seas

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Epeiric seas were common in deep times, but modern analogues are rare. Reconstruction of ancient examples is usually limited by available data, which also hampers the conceptualization of their variability and key controlling parameters. In this study we summarize and integrate a large stratigraphic dataset of a relatively small, semi-restricted Cretaceous epeiric sea in SW Gondwana to reconstruct oceanographic connection with adjacent ocean through time, areal distribution of sediments entering the marine basin, and sediment dispersal pathways within it. The Valanginian–Hauterivian study interval represents an exceptional record of continental and marine sediments deposited in the Neuquén Sea, semi-connected with the proto-Pacific Ocean across a volcanic arc. This interval is organized in three transgressive–regressive sequences (Lower, Middle, and Upper) defined by linked depositional systems, macrobenthic bioevents, and stratal patterns. Paleogeographic reconstructions show a consistent E–W proximal–distal depositional trend and a major fluvial system located in its SE apex. Dispersal pathways within the distal marine settings allow defining a non-uniform, along-depositional strike scenario, with a locus of siliciclastic deposition westwards of a major deltaic system and increasing carbonate contribution away from it. The degree of connection between the Neuquén Sea and the ocean varies over time with a probable peak near the base of Middle Sequence. Key attributes reconstructed for the Neuquén Sea, namely significant restriction, major sediment supply in one apex, and asymmetric distribution of sediments in the distal settings, are comparable with configurations observed in the present Persian Gulf and Adriatic Sea. Comparisons with ancient examples (e.g., Western Interior Sea or North American Seaway) suggest contrasting paleogeographic models, but at the same time reinforce the value of these key parameters to produce better discrimination between the possible spectrum of epeiric seas. In that sense, building classifications for epeiric seas based on these parameters (size, degree of ocean connection, sediment entry points, and sediment pathways), appears as the next challenge for better reconstructions of these environments worldwide.

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Special Session 12.3. The stratigraphic record of paleoenvironmental variation in epeiric basins

Oral presentation

A multiproxy study of a sequence boundary formed during isolation of an epicontinental basin: the Sarmatian–Pannonian transition in the Vienna Basin, Slovakia

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The aim of this study was to analyze temporal and spatial changes in paleoenvironments from demise of the Sarmatian Sea to the Lake Pannon transgression (~11.6 Ma), as an example of a sequence boundary in a semi- to fully isolated epicontinental basin. Borehole cores from the central Vienna Basin were subject to facies analysis, biostratigraphy, geochemistry and authigenic $^{10}Be/^{9}Be$ dating, and seismic stratigraphy supported with study of well-logs served for correlation of the observations. The uppermost Sarmatian deposits consist of a wide variety of facies from well-bioturbated offshore muds to hyperpycnal flow beds and wave-current facies. The environment exhibit a variation from oxic to dysoxic conditions with probable freshwater input. The pronounced high amplitude reflectors of the lowermost Pannonian horizon (30–70 ms thick (TWT)) are bounded from below by an undulated erosional unconformity. A lateral transition of facies could be traced from most proximal sand-dominated wave-current deposits, to hyperpycnal upward-fining strata and distal poorly laminated and bioturbated muds. The conditions of the earliest Pannonian environment were dysoxic, in accordance with an extremely low diversified marsh association of foraminifers tolerating oxic stress, and precipitation of carbonates took place. The overlying Pannonian interval consists of up to 130 ms thick clinoforms (shelf–slope scale), mirroring a transgression event. It is associated with a monotonous muddy deposition of slow traction currents and distal hyperpycnal flows. Proportion of carbonates decreased, input of coarse silt is higher and oxic/dysoxic conditions with presumable freshwater inflow recovered. The deepening of Lake Pannon caused significant nutrient supply increase, indicated by diatom blooms. The authigenic $^{10}Be/^{9}Be$ dating weighted mean age of 10.84 ± 0.16 Ma for the lowermost Pannonian horizon imply either a period of subaerial exposure ~0.8 Myr long, a very condensed deposition, or erosion of the earliest Pannonian strata.

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Theme 12. Stratigraphic markers and archives

Special Session 12.3. The stratigraphic record of paleoenvironmental variation in epeiric basins

Oral presentation

Discriminating between sedimentological and biogenic shell beds in an epicontinental sea during the Holocene (northern Adriatic Sea)

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Preservation of shell beds or shell concentrations can be diagnostic of conditions with pervasively reduced net sedimentation rates and (e.g., identifying sequence-stratigraphic surfaces) but also can reflect ecosystem conditions characterized by high net carbonate production (biogenic shell beds). Low net sedimentation rates can lead to condensation and high time averaging of fossil assemblages, which can in turn increase their taxonomic diversity and evenness. Inverse relation between sedimentation rate and shelliness and positive relation between evenness and shelliness are thus expected to be observed in condensed (sedimentological) shell beds. Here, to assess whether sedimentological and biogenic shell beds can be empirically discriminated in an epeiric basin during the Holocene, we assess the relationship between shelliness (density of fossil remains) and net sedimentation rate and between shelliness and taxonomic evenness of molluscan assemblages in sediment cores collected in the NW and NE Adriatic Sea. Although ecosystem dynamic can confound these expectations, we show that (1) the relation between sedimentation rate and shelliness is moderately negative and (2) the relation between evenness and shelliness is moderately positive in the Holocene record of the northern Adriatic Sea. Although these overall relations indicate that most shell beds were formed under slow sedimentation, some assemblages are uneven, did not form under slow sedimentation, and rather correspond to biogenic shell beds. Evenness is bimodally-distributed in shell beds, with (1) one subset of shell beds represented by highly uneven assemblages dominated by opportunistic bivalve species that inhabited the shallowest (intertidal and upper shoreface) environments, and (2) another subset represented by highly even assemblages that originated in deeper (offshore transition) environments. We suggest that the bimodality in evenness can discriminate between biological, weakly time-averaged shell beds (with low evenness) and condensed, highly time-averaged shell beds (with high evenness).

Theme 12. Stratigraphic markers and archives

Special Session 12.3. The stratigraphic record of paleoenvironmental variation in epeiric basins

Poster presentation

Carbon isotope record and palynostratigraphy of the Lower–Middle Triassic boundary in the Holy Cross Mountains (Poland, southern Germanic Basin)

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The uppermost Olenekian–Lower Anisian carbonate succession in the western Holy Cross Mountains (central Poland) represents a carbonate platform developed in the southern Germanic Basin (Peri-Tethys Domain) in response to its connection with the Tethys Ocean throughout the tectonically-driven depressions, i.e. the Silesian–Moravian and East–Carpathian Gates. This succession has been thoroughly studied in the Podzamcze IG-1 drilling core, taking into account the sedimentological aspects, carbon isotope signature and palynostratigraphy. The sedimentary record is dominated by marly and nodular limestones interbedded with marls and storm-related crinoid/mollusc coquinas. Subordinate facies are represented by the early diagenetic dolostones with diminutive microbial fabric as well as red mudstones with initial paleosols. In palynostratigraphic terms, the studied section includes the *Angustisulcites gorpii–Voltziaceaesporites heteromorpha* through *Striatoabietites balmei–Voltziaceaesporites heteromorpha* to *Protodiploxypinus doubingeri* zones (sensu Kozur, 1999), that is the transition from the Lower to Middle Triassic. The $\delta^{13}C$ signature of the uppermost Olenekian–Lower Anisian carbonates (from bulk samples) ranges from -5.66 to 2.91 ‰V-PDB, and reveals an overall increasing trend with four conspicuous excursions. Two lower excursions (0.23 and 1.14 ‰, respectively) occurs across the Spathian–Anisian boundary, the second one (0.43‰) correlates with the Aegean/Bithynian boundary zone, and the prominent shift to 2.91‰ is located in the Bithynian–Pelsonian transition. The $\delta^{13}C$ fluctuations in the Podzamcze IG-1 well correspond to depositional cycles displaying shallowing upward trend and can be correlated with third-order transgressive–regressive sequences recognized in the same stratigraphic interval of the Upper Silesian Triassic (Szulc, 2000). The regressive part of each cycle is marked by dolostone facies or pedogenic red mudstones.

References

Kozur H.W. (1999) The correlation of the Germanic Buntsandstein and Muschelkalk with the Tethyan scale. Zbl. Geol. Paläont., T. I (1998), 7–8, 701–725.

Szulc J. (2000): Middle Triassic evolution of the northern Peri-Tethys area as influenced by early opening of the Tethys Ocean. Annales Societatis Geologorum Poloniae, 70, 1–48.

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Special Session 12.3. The stratigraphic record of paleoenvironmental variation in epeiric basins

Poster presentation

Sedimentary evolution of the final stages of an epeiric sea in the NW of South America: a sedimentological and ichnological approach

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The NW of South America (Colombia) was divided during the Cretaceous into two geological domains. The eastern domain associated with the margin of the South American Plate and the western domain linked to the Caribbean Plate. Over the eastern domain, an extensional phase allowed the development of an epeiric sea since Early Cretaceous, which extends until the end of the Cretaceous. This research focuses on the sedimentological and ichnological characterization of Campanian–Maastrichtian deposits that constituted the external borders (east and west) of the epeiric basin which reached approximately ~500 km in width. In the western side, the Campanian is mainly represented by sandstones, mudrocks, limestones, chert and marls, locally with *Thalassinoides* related to foreshore–shoreface and shelf environments. The Maastrichtian is composed by mudrocks, marls and locally sandstones and limestones, with *Asterosoma*, *Chondrites*, *Ophiomorpha*, *Palaeophycus*, *Planolites*, *Schaubcylindrichnus*, *Scolicia*, *Taenidium*, *Teichichnus* and *Thalassinoides* linked to shoreface–offshore and shelf settings. These deposits are overlain by Maastrichtian conglomerates, sandstones and locally mudrocks with *Ophiomorpha* and *Thalassinoides* related to braided delta deposits, which are overlain by sandstones, mudrocks and coal, with *Arenicolites*, *Rhizocorallium*, *Taenidium* and *Thalassinoides* linked to tidal, swamps, lagoon and fluvial settings. In the eastern side, the Campanian is represented by sandstones and mudrocks with *Ophiomorpha*, *Palaeophycus*, *Planolites*, *Rhizocorallium* and *Thalassinoides* related to shoreface–offshore settings, influenced by hyperpycnal flows, which are overlain by mudrocks, with very scarce bioturbation, associated with offshore–shelf environments. The Maastrichtian is composed of sandstones, mudrocks and conglomerates with *Conichnus*, *Palaeophycus*, *Planolites*, *Rhizocorallium*, *Taenidium*, *Teichichnus* and *Thalassinoides* linked to shoreface–offshore settings, with hyperpycnal flows influence. The integration of sedimentology and ichnology allows recognition of differences in the physical and ecological depositional parameters in both sides of the epeiric basin, which can be associated with variable processes and/or geological configurations controlling the sedimentation.

Theme 12. Stratigraphic markers and archives

Special Session 12.3. The stratigraphic record of paleoenvironmental variation in epeiric basins

Poster presentation

Badenian sedimentary succession of the Mestinje Anticline (western Central Paratethys)

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NE Slovenia is situated in the western margin of the Pannonian Basin System. The area is covered with sediments deposited in the Central Paratethys. In the present study, a middle Miocene (Badenian) succession in the Mestinje section near Rogaška Slatina was recorded and sedimentologically and paleontologically analysed. The studied sequence is part of the informally known Laško formation, which is commonly composed of two lithologies: the Laško marl and Lithothamnium limestone. In general, the strata of the Laško formation are in discordant contact with the underlying Eggenburgian layers, and the sequence starts with basal conglomerates overlain by sandstones, marly limestones and marls. Locally, calcarenite is also present. The outcrop of Mestinje does not contain all the elements of the Laško formation. The sedimentological analysis is based on a detailed sedimentological description of the sections and petrology. The lower part of the section consists of calcareous sandstones with shell fragments and fine- to coarse-grained sandstones. The upper part is characterised by alternating fine to medium-grained sandy limestones and fine to coarse-grained sandstones with weathered marly siltstones, which are sometimes laminated and containing shell fragments. Individual beds pinch-out laterally. An abundance of alochemical components is consistent with warm water conditions supporting high productivity that corresponds to the Middle Miocene Climatic Optimum. Studied nannofossil assemblages are moderately preserved, relatively diverse and composed of cosmopolitan species. This suggests a functional marine connection of the Central Paratethys with the World Ocean. The Mestinje outcrop is a prominent anticline and the only visible fold of Miocene-age deposits in Slovenia. For this reason, the outcrop has been protected as a valuable natural value.

Theme 12. Stratigraphic markers and archives

Special Session 12.3. The stratigraphic record of paleoenvironmental variation in epeiric basins

Poster presentation

Basin circulation controlling the sedimentologic and ichnologic record of the fine-grained Vaca Muerta Formation (Upper Jurassic–Lower Cretaceous, Argentina)

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Black shale studies have traditionally highlighted the impact of basin circulation in the stratigraphic and sedimentologic record of ancient basins, due to its effect in the distribution of sediments and the renewal of deep water masses. A sedimentologic and ichnologic analysis was carried out in the Vaca Muerta Formation fine-grained clinoform system (Upper Jurassic–Lower Cretaceous, Argentina) to create a robust depositional model and evaluate the control of basin circulation during deposition. Sedimentary facies were defined in cores from eight wells and one outcrop (total of 988.5 m). Forty-one facies were clustered into thirteen facies associations, constituting marginal marine, basin, drift, and slope environments. The marginal marine deposits comprise fine- to coarse-grained sandstone, bindstone and mudstone accumulated in beach and bay environments. The basin deposits are composed of fine mudstone interbedded with tuff, produced by pelagic, hemipelagic and rare flow, current and storm deposition. The drift deposits consist of crinoidal mudstone and fine to coarse mudstone and originated under contour current reworking. The slope deposits comprise calcareous fine to coarse mudstone, generated by pelagic, hemipelagic, and fluid mud deposition. Basin-wide circulation is interpreted as the underlying control for these deposits. During estuarine circulation, bottomset and foreset record basin and slope environments showing pelagic, hemipelagic, and fluid mud sedimentation. Anoxic or euxinia to lower dysoxic conditions were dominant. In contrast, weakened estuarine or anti-estuarine circulation developed bottomset and foreset with basin and drift environments affected by pelagic, hemipelagic, and contour current transport. Dysoxic to oxic conditions were common. A relative cooling and arid event during the late Tithonian indicates that climate could have been the triggering factor for anti-estuarine circulation, associated with higher winter convection and decreased freshwater input. Hence, this study demonstrates the critical effect of basin circulation on sediment distribution and bioturbation along a clinoform system, suggesting that its evaluation should be adequately considered in depositional models.

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Special Session 12.3. The stratigraphic record of paleoenvironmental variation in epeiric basins

Poster presentation

Late Jurassic sequence stratigraphy and sedimentology of shallow marine coarse grained siliciclastic deposits in the southern Utsira High: deciphering the intra Draupne Formation in the Johan Sverdrup field

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Coarse grained mud-free shallow marine successions are difficult to describe and interpret, especially in the subsurface. On the other hand, they are excellent reservoirs due to its high net-to-gross ratio. The Intra Draupne Formation in the Johan Sverdrup field clearly exemplifies these concepts. Deposited during Oxfordian to Volgian times in the Southern Utsira High, it is one of the biggest and best reservoirs ever discovered in the Norwegian North Sea. Description and interpretation of 22 exploration well cores, seismic sections and multiple correlation panels are the basis for a basinwide sequence stratigraphic model that unravels the detailed depositional history of the succession and places its formation within a regional Late Jurassic tectonostratigraphic framework. Four different parasequence sets were deposited during the Kimmeridgian to Volgian interval following a regional Kimmeridgian flooding. The basin is characterized by a narrow half graben, the Augvald Graben, bounded by the granitic Haugaland and Avaldsnes highs, which acted as source areas. With sediments mainly supplied through Haugaland sourced fan deltas and longshore currents reworking the Avaldsnes High, the first parasequence shows a unique suite of facies consisting of fine grained and mud-rich bioturbated sandstones deposited in a protected back-barrier lagoon. Subsequent parasequences lack fine grained sediments and are dominated by bidirectional cross stratified coarse-to-very coarse sandstones and gravels forming different types of barforms. The opening of a deep and narrow strait in the Early Volgian due to tectonic subsidence at the main faults enhanced current circulation in the basin and promoted the deposition of clean coarse grained clastics. A progressive decay of fault related subsidence in the late Middle Volgian along with Late Volgian–Ryazanian sea level rise and inversion of pre-existing structures, promoted backstepping of the feeder systems, sediment starvation and the progressive deposition of the black and green-red shales of the Draupne and Asgard Formation.

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Special Session 12.5. Paleoclimate and paleoenvironmental changes in shallow-marine seas

Oral presentation

Increased biogeochemical weathering during the Middle Eocene Climatic Optimum (MECO): insights from trace element analyses and Sr isotope ratios from a shallow water carbonate succession of the Ligurian Alps (Northern Italy)

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The Middle Eocene Climatic Optimum (MECO, 40.5–40 Ma) is one of the most abrupt global warming pulses of the Cenozoic. The MECO was recognized as a >1‰ negative shift in deep-sea oxygen isotopes records, whereas its signature has been significantly overlooked in shallow water settings. The present study aims at identifying the impact of this warming pulse on a shallow-water, mixed carbonate–siliciclastic succession exposed in the Capo Mortola section (Ligurian Alps, Northern Italy) by a multiproxy approach based on facies and microfacies analyses, trace element concentrations, magnetic susceptibility, clay mineral assemblages and Sr isotope ratios analyses. Age constraints come from Large Benthic Foraminifera and nannofossil biostratigraphy. The facies analyses of the Capo Mortola section show a significant change during MECO (nannofossil Subzone MNP 16Ba or uppermost Zone CNE14), when nummulitid-rich rudstones to packstones are replaced by marly wackestones to floatstones with solitary corals and ostreids. An increase of terrigenous input during the MECO is marked by a mild increase of continental-derived elements such as Al, Si and Fe, the latter testified by positive spikes in the magnetic susceptibility values. Furthermore, Sr isotope ratios measured on selected, well-preserved ostreid shells are below the global reference Sr isotope curve for the middle Eocene. This mismatch testifies for an increased weathering of alpine crystalline rocks and likely for a weakened water circulation enhanced by global warming. These results are particularly interesting since they document the detrimental conditions for carbonate production during this extremely warm event. In the end, this study stresses out the multiple factors that can affect the Sr isotope signature of seawater in the deep past, highlighting potential limits in the application of Sr isotope stratigraphy in mixed carbonate–siliciclastic successions during particular climatic events.

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Oral presentation

Expression of large-scale sea-level oscillations in a marginal shallow marine bay (Aptian, Spain)

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The sequence stratigraphy and palaeogeographical evolution of an Aptian shallow-marine bay in the Western Tethys has been reconstructed through detailed analysis and correlation of 10 bed-by-bed logs spanning the Aptian stratigraphic record of the Oliete subbasin (Maestrazgo Basin, Eastern Iberia). Three third-order transgressive–regressive (T–R) sequences have been identified. The newly defined Tejería Formation represents a highly asymmetric T–R cycle, with a short transgressive hemicycle culminating in a condensation level with diverse ammonite faunas of the *Deshayesites forbesi* biozone, and a regressive hemicycle representing the progradation of a deltaic complex, characterized by a transition from prodelta clays with intercalated sandstone levels with hummocky cross-stratification, to high-energy sandy shoreface facies containing abundant endobenthic bivalves (Pholadomyidae, Trigoniidae). A prominent subaerial exposure surface on top of the Forcall Formation marks a sharp change in the depositional system towards the low-energy lagoonal carbonates of the lower Oliete Formation, which contain abundant articulated bivalves and gastropods, colonial corals and pervasive *Thalassinoides* bioturbation. This interval represents a second T–R cycle topped by a second subaerial exposure surface associated to the development of lateritic paleosols with abundant iron ooids. Above this surface, the last T–R sequence (upper Oliete Fm) is characterized by a variety of low-energy shallow subtidal and peritidal facies associated to massive oyster rudstones and accumulations of articulated endobenthic bivalves, as well as very scarce ammonites of the *Parahoplites melchioris* and *Acanthoplites nolani* upper Aptian biozones. This upper interval is topped by a karstified discontinuity surface recognizable basinwide, which marks the transition to the restricted marine and continental deposits of the Escucha Fm. The two subaerial exposure surfaces found at the top of T–R sequences 1 and 2 have been reliably linked to significant eustatic sea-level drops previously described by other authors in different areas of the Tethys.

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Oral presentation

The influence of Taiwan orogenesis on the preservation of climate signals

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Changes in Earth's eccentricity, obliquity, and precession cause climate variations over kyr- to myr-scales that may be preserved in sedimentary archives. In mid- to low-latitude regions, shallow-marine sedimentary records have been shown to record changes in precession-driven hydroclimate. However, understanding climate change in the geological past is challenging because many proxies are sensitive to forcings independent of climate. Our study aims to resolve the influence of a rapidly uplifting orogen on climate cycles preserved in shallow-marine strata of the Kueichulin Fm in Taiwan's Western Foreland Basin (WFB).

We integrate magnetobiostratigraphy and cyclostratigraphy of borehole gamma-ray data, as well as outcrop data ($\delta^{13}C_{org}$ and magnetic susceptibility) from the Kueichulin Fm. The data were then compared to East Asian Summer Monsoon (EASM) records from the South China Sea to evaluate the influence of Taiwan orogenesis on these proxies.

Time-series analysis shows that during the early stages of Taiwan orogenesis (predating 5.4 Ma), preservation of precession signals was low as the Taiwan Strait had not yet formed, leaving the WFB open to erosion by waves from the Pacific Ocean. From 5.4–4.9 Ma, the preservation of orbital cycles remained low due to low sedimentation rates at deeper water depths, and/or undetectable cycles due to homogeneous lithology. With continued rapid uplift and erosion after 4.9 Ma, the Taiwan orogen became a dominant sediment source and shielded the WFB from erosive waves. This, combined with increased basin accommodation, resulted in enhanced preservation of precession signals. The emergence of the Taiwan orogen also clearly impacted EASM records from the South China Sea, wherein variations in proxies are influenced by sedimentation from Taiwan independently from changes in EASM intensity.

Our study shows how a rapidly uplifting orogen can modify the expression of orbital climate forcing imprinted in shallow-marine sedimentary archives at different stages of orogenesis. Our findings also highlight the importance of identifying changes in sedimentary proxies that are forced by processes independent of climate. Specifically, the impact of shifting sediment source on EASM proxy records must be considered to accurately interpret past climate changes in the South China Sea.

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Oral presentation

Sequence stratigraphy of the Upper Cretaceous–Eocene Belqa Group of Jordan

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The Belqa Group of Jordan (Upper Cretaceous–Eocene) contains a remarkable succession of sedimentary lithofacies, including chalk, sandstone, chert, phosphorite, oyster mounds and organic-rich marls deposited along the passive southern margin of the Neo-Tethys Ocean. Exceptional outcrop exposures along deep wadis display the 3D facies variations and their stratigraphic distribution. We report the establishment of a regional sequence stratigraphic model that provides the temporal framework for further detailed sedimentological, palaeontological and geochemical studies. Preliminary results show a stratigraphic organization in four major depositional sequences, which are broadly in agreement with the lithostratigraphic formations. The age dating is based on new nano-fossil analyses and C/O and Sr isotope stratigraphy. A subdivision into higher-frequency sequences significatively improves the resolution of the stratigraphic framework and our understanding of spatio-temporal distribution of the sedimentary facies. The four sequences are: (1) the Wadi Umm Ghudran sequence (Upper Coniacian–Santonian), characterized by a transgressive phase of chalk-rich sedimentation (coccolithophore-dominated) and a regressive phase of a prograding siliciclastics with a distal transition to the first phosphorite-chert facies; (2) the Amman Silicified Limestone sequence (Lower Campanian) also starts with a transgressive chalk dominated facies and subsequently develops into a chert-dominated marl facies (radiolarian-dominated). The chert is locally associated with thin phosphates and coquinas; (3) the Al-Hisa Phosphorite sequence (Upper Campanian), which is characterized by dm- to m-thick phosphorite beds that were deposited coevally with giant oyster banks (decameter scale); (4) the Muwaqqar–Chalk–Marl Formation (Maastrichtian–Paleocene), represents a dramatic facies change to organic-rich pelagic marls, and can probably be further subdivided. This sedimentary succession highlights both gradual and rapid changes in biogenic productivity and geochemistry. These changes are punctuated and partly driven by significant relative sea-level changes, and likely also larger scale palaeoceanographical processes that are the focus of future work.

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Oral presentation

Glendonite-bearing concretions from the Late Pliensbachian (Lower Jurassic) of southern Germany – indicators for a massive cooling in the European epicontinental sea?

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The Early Jurassic climate was characterised by pronounced fluctuations. Phases of rapid global warming were intermitted by periods of rather cold climate. One example is the transition from the late Pliensbachian to the early Toarcian. The Toarcian Oceanic Anoxic Event (T-OAE, Jenkyns Event) marked a severe biotic crisis caused by increased volcanic activity and associated global warming and was preceded by a cooling event in the late Pliensbachian whose cause, intensity and extent are still discussed. Occurrences of glendonite from Siberia and Northern Germany play an important role in this debate since glendonite is a pseudomorph after the cryophilic carbonate mineral ikaite. However, the use of glendonite as a proxy for near-freezing water temperatures has been challenged in the past years. In this presentation, the first glendonite-bearing carbonate concretions from a shallow marine succession in Southern Germany are described, which represent the so far southernmost glendonite occurrence in the late Pliensbachian. This finding raises the question whether the formation of precursor ikaite was triggered by a massive temperature drop or by geochemical processes in the shallow subsurface favouring the precipitation of authigenic carbonates, for example methane seepage. Stable carbon isotope values between -21.82 and -10.34 ‰ VPDB suggest a formation of the studied glendonites in the sulfate reduction zone. Though minor contributions of HCO_3-derived by the anaerobic oxidation of methane cannot be excluded, lacking sedimentological evidence in the studied succession make methane seepage as a trigger unlikely. This suggests that a low temperature was the main factor for ikaite formation in the study area. Moreover, multiple hiatus concretion-bearing layers, which mark phases of sediment reworking, occur in the studied outcrop, of which one is associated with the glendonite-bearing interval. These hiatuses were caused by sea level drops, that were probably driven by glacio-eustatic processes, and therefore corroborate the assumption of a massive cooling during the late Pliensbachian, which extended into the central part of the European epicontinental sea.

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Oral presentation

Watermass reconstruction in the Variscan foreland basin based on integrated proxies of redox conditions, salinity, and nitrogen cycling in Mississippian to Pennsylvanian Namurian Shale, Belgium and S-Netherlands

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Redox conditions and salinity are essential features of watermass acting as key factors for the composition of sediments. During the late Mississippian to early Pennsylvanian, the Namur Synclinorium and Campine Basin at the north of the uprising Variscan mountains were characterized by the deposition of organic-rich mudstones. Watermass reconstruction and its spatial distribution were performed based on the analysis of a large sample set from five wells. New inorganic, isotope, and organic geochemical data were acquired in this study in order to reconstruct redox conditions, salinity, and nitrogen cycling on a broad geographic scale. Organic carbon and nitrogen contents and isotope data, along with major and trace elements, were used to provide a combination of multiple paleo-environmental proxies. Oxygen-depleted environments occurred during the early Namurian A stage, especially near the basin floor in contrast to more oxygenated environments during the late Namurian A stage, especially near the basin margin. From the basin floor to the margin, redox conditions changed from mainly euxinic to anoxic conditions with some dysoxic episodes to mainly anoxic to dysoxic conditions with a few oxic episodes. Variations in bulk nitrogen stable isotope values suggest that nitrogen fixation, nitrification, denitrification, and anammox processes occurred in the water column under appropriate redox conditions. Nitrogen fixation dominated in anoxic environments, while nitrification, denitrification, and anammox processes dominated in anoxic to dysoxic environments with oxic episodes. Marine, brackish, and freshwater conditions existed in the Campine Basin and Namur Synclinorium, with marine and brackish water being the dominant environments. Salinities progressively declined with time, especially near the basin margin, representing increasing freshwater input into the basin.

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Poster presentation

Depositional system change at the Campanian–Maastrichtian boundary: from cherty phosphates and oyster mounds to organic-rich shales (Southern Tethys margin, Jordan)

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Upper Cretaceous Al Hisa Phosphorite (AHP) and Muwaqqar Chalk Marl (MCM) formations located in western Jordan are characterized by a particular facies association including phosphate deposits, oyster mounds, and organic-rich lithofacies, all of which have economic importance in the region. The present work investigates their sedimentological, geochemical, and stratigraphic evolution. This study combines well-exposed outcrop observations with shallow-cored wells (up to 70 m deep) and a regional set of gamma-ray logs. A total of 191 samples have been analysed for mineralogical content, carbon ($\delta^{13}C_{org}$ and $\delta^{13}C_{carb}$) and oxygen ($\delta^{18}O$) isotopes, TOC content, natural gamma-ray spectrometry, palynology, nannofossils and dinoflagellates for age dating, and microfacies types. The preliminary results show that: (1) the marine decimeter to meter thick phosphate-rich intervals were deposited coevally with the oyster mounds. The oysters are exceptionally large (up to 20 cm in length), and locally preserved in situ forming a topographic relief of up to 20 m; (2) the overlying, carbonate mudstone, deposited in deeper water conditions, is locally rich in planktonic foraminifera and organic matter showing up to 22 wt%. (3) nano-fossils and dinoflagellates are used for age dating and place the facies transition at or around the Campanian–Maastrichtian boundary, (4) the regional stratigraphic and well log correlations show that this rapid facies transition can be traced across Jordan from N to S, and (5) in this overall nutrient-rich environment, the coupling/decoupling of the $\delta^{13}C_{org}$ and $\delta^{13}C_{carb}$ with quantitative analysis of the dinoflagellate cyst species can be used to discuss the palaeoproductivity and its impact on the transition from the AHP to the MCM. The ongoing data integration analysis will further address the environmental and geochemical conditions, and timing of this drastic facies transition, with the aim to place it in the broader context of similar sedimentation patterns observed along the southern Neo-Tethys Ocean.

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Poster presentation

Sedimentary records associated with the dynamics of the Mittie Glacier (Smith Bay, Nunavut, Canada) during the Holocene

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The history, controls and processes of advance and retreat of marine-terminating modern glaciers of the eastern Canadian Arctic Archipelago remain poorly documented, undermining assessments of their dynamics and associated contribution to global sea-level rise in a warming climate. The study of long-term sedimentary records near marine-terminating glaciers can help us better understand the dynamics of these glaciers beyond the instrumental record as well as the impact of future climate changes. In this context, this study focuses on a set of sediment cores collected in Smith Bay and at the front of Mittie Glacier (southeast Ellesmere Island) onboard the CCGS Amundsen during the 2021 ArcticNet expedition. We use physical, sedimentological, mineralogical, and elemental geochemical (pXRF) properties to 1) document sediment composition and lithofacies and 2) reconstruct changes in sediment transfers from the Mittie Glacier and Makinson Inlet related with the Holocene climate variability. Preliminary sedimentological results reveal three distinctive lithofacies (LFs) at Smith Bay and Mittie. At Smith Bay, LF1 is characterized by a silty, ice rafted debris (IRD) rich mud suggesting high calving activity related with deglaciation of Smith Bay during the Early Holocene, LF2 by a sandy mud with disseminated IRD and high SS_{mean} values indicating sediment deposition influenced by meltwater outwash and increased water flow velocity during the Middle Holocene and LF3 by a clayey mud with disseminated IRD and a decrease in SS_{mean} values suggesting a decrease in sediment transport intensity during the Neoglacial period. In Mittie, LF1 is characterized by IRD-rich sediments that suggest increased iceberg calving during the Early Holocene, LF2 is characterized by massive sediments with low IRD and high SS_{mean} values suggesting sediment deposition influenced by glacial meltwater plumes and increased water flow velocity during the Middle Holocene and LF3 is IRD-rich clayey mud with some turbidites suggesting increased iceberg calving activity and large glaciogenic meltwater discharge events during the Neoglacial period. The timing of these LFs needs to be confirmed by the radiocarbon dating and ^{210}Pb measurements that are currently in progress.

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Special Session 12.5. Paleoclimate and paleoenvironmental changes in shallow-marine seas

Poster presentation

Extending the spectrum of storm-flood deltas: examples from a high-latitude deltaic system during the Early Cretaceous

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Storm-floods refer to the simultaneous occurrence of river floods caused by high inland precipitation and storm waves in the nearshore realm as a result of strong winds. This interplay of processes has significant impacts on shoreline geometry and sediment distribution, and has been documented in the stratigraphic record of ancient tropical deltas affected by the monsoon. These deltas are widely regarded to develop along tectonically active margins characterized by narrow, steeply dipping coastal zones drained by multiple rivers with short courses (< 300 km), coupled with high subsidence and aggradation rates. The present study focuses on the Lower Cretaceous Grand Rapids Formation and offers an alternate climatic and tectonic setting in which storm-floods, albeit less energetic than their tropical counterparts, can also operate and be preserved. The Grand Rapids Fm is arranged in 5–15 m-thick coarsening-upward bedsets that can be correlated regionally in the Western Canadian Sedimentary Basin. Such bedsets record the progradation of clastic shorelines into the shallow Boreal Sea located at cold-temperate paleolatitudes (~60^0N) and fed by northward-flowing, continental-scale rivers (> 1000 km). Facies successions exhibit hummocky cross-stratified and oscillatory ripple cross-laminated sandstone capped by sharp- to scour-based, massive to normal-graded mudstone beds locally containing abundant syneresis cracks. Impoverished ichnofauna and variable bioturbation intensities reflect intermittently stressed and brackish-water conditions typical of deltas. These facies are characteristic of storm-dominated prodelta and delta-front systems, and record storm-flood processes during which mud was deposited either as flood-induced hyperpycnites or by rapid settling from buoyant (hypopycnal) plumes. In contrast to the tectonic and paleoclimatic setting of other storm-flood dominated intervals, the Grand Rapids Fm shows widespread storm-flood cycles despite occupying a high-latitude, low-accommodation foreland basin characterized by shallow-gradient coastal zones. In such successions where oscillatory structures are ubiquitous, the distance to the river mouth may be primarily expressed in the intensity of biogenic reworking and the diversity and distribution of trace-fossil suites.

Theme 12. Stratigraphic markers and archives

Special Session 12.5. Paleoclimate and paleoenvironmental changes in shallow-marine seas

Poster presentation

Late Holocene rapid infill history in the Seomjin river estuary, south coast of Korea

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Rapid transgression associated with sea-level rise occurred normally during the early Holocene, leading to estuarine infills along the incised valleys by marine flooding. However, the timing and evolution pattern of post-glacial transgression are diverse. Fluvial sediment discharges related to monsoon climate in the East Asia varied significantly during the Holocene. In the present study, we document the Holocene infill history at the mouth of the Seomjin river estuary, where the estuarine and fluvial processes interact. Sedimentary facies analysis has been conducted from two long drill-cores obtained in the river estuary, and ^{14}C-AMS dating method was applied for the chronostratigraphic analysis. Facies analysis reveals that more than 30 m thick of Holocene deposits consist of two units, i.e., Lower and Upper units. Lower unit is ca. 16 m thick and is characterized by homogeneous muds with shelly mud layers and slightly interbedded sand laminae. Shell fragments and organic matters are scattered locally in this unit. The unit is interpreted as estuarine mud flat with some tidal signatures. About 16 m thick of Upper unit, overlie sharply the lower unit. Homogeneous muds and parallel-laminated sandy muds with shell fragments and terrestrial organic matters constitute the major facies of Upper unit, being interpreted as estuarine channel fills. AMS radiocarbon dating indicates the Upper channel fill unit formed within 1 ka B.P., suggesting very rapid accumulation (~1.6 cm/yr), possibly discharged by dramatic increase in summer-monsoon intensity. Such high sedimentation rates in a short period are comparable to those of the large rivers. Intensified summer monsoon may not alone result in high sediment discharge in this relatively small river. Other source of fine sediment loads may be involved. The source of the fine sediments remains obscure and should be clarified in the future.

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Special Session 12.5. Paleoclimate and paleoenvironmental changes in shallow-marine seas

Poster presentation

Characterization of *Halimeda* bioherms of the pre-evaporitic Messinian of the Salento Peninsula (Southern Italy)

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Calcareous green algae bioherms are assuming a central role in scientific field in recent times as they represent a stratigraphic and paleoecological archive comparable to that of coral reefs. Currently, the genus *Halimeda*, very abundant in tropical settings and common in temperate ones, contributes in a significant way to the production of sediments rich in $CaCO_3$. This is due to a rapid calcification process that occur in its peculiar internal structure. Halimeda bioherms represent a key case because of their non-continuously distribution in the stratigraphic record. As a matter of fact, these lens-shaped buildups are reported only in few localities of the Mediterranean basin belonging to the pre-evaporitic Messinian. In this study, we present data carried out from stratigraphic and sedimentological analysis of two *Halimeda*-rich deposits, with a maximum lateral extent of about 30 m and thickness of 5–6 m, located in the southernmost portion of the Apulia Carbonate Platform (Salento Peninsula). Field observations coupled with thin sections analysis show that, despite these two sections are ascribed to different stratigraphic intervals, both record the same facies with the relative variations indicating a certain cyclicity. It is not yet clear if the occurrence of Messinian *Halimeda*-rich facies could be related to internal control factors such as their bathymetric position, or external ones such as relative sea level fluctuations or others. Furthermore, the occurrence of upwelling of nutrient-rich cool waters recorded during the latest Tortonian in many Mediterranean areas can be another important factor to be considered, as documented in the wide modern analogues *Halimeda* bioherms of the Great Barrier Reef.

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Poster presentation

Warmer gets sandier? The paleoenvironmental record of hyperthermal events in coastal environments during the Early Eocene Climate Optimum (South Pyrenean Foreland Basin, Spain)

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The Early Eocene Climate Optimum (EECO; 49.14 to 53.26 Ma) was characterized by high atmospheric CO_2 concentrations and high global temperatures. Moreover, this period was also marked by several hyperthermal events, abrupt and major releases of isotopically depleted carbon into the atmosphere, expressed by remarkable negative carbon isotope excursions (NCIEs) in sedimentary records. These hyperthermal events were associated with rapid temperature increases, postulated to have enhanced precipitation and possibly erosion and chemical weathering on land. Hence, these hyperthermal events should have increased clastic sediment production and delivery to the ocean. To test this hypothesis, we here analyze the paleoenvironmental record of the Castigaleu sequence (Early Eocene; Ypresian; 52–50.2 Ma), which is exposed in the South Pyrenean Foreland Basin (SPFB) near Navarri (Aragon, Spain). A 643.5 m thick mixed siliciclastic–carbonate section was logged and sampled (n = 301). Sedimentary facies analysis was complemented by mineralogical (whole-rock XRD), geochemical (organic carbon stable isotopes: $\delta^{13}C_{org}$), and organic matter characterization (Rock-Eval pyrolisis analysis). This multi-proxy approach aimed to determine variations and trends during the deposition better to understand the influence of hyperthermal events on coastal environments. The results suggest that deposition began in a mid-ramp bioclastic-rich environment and evolved vertically into a siliciclastic-prone fluvial-dominated deltaic system with subordinate wave influence. The onset and progradation of this deltaic system, marked by the abrupt appearance of m-thick cross-stratified medium-grained sandstone, coincides with the first NCIE recorded in the stratigraphic section. Successive pulses of progradation correlate with subsequent NCIEs. Despite the Pyrenean orogeny, hyperthermal events were of higher frequency than the growing Pyrenees, facilitating their detection from the $\delta^{13}C_{org}$ record. In turn, this suggests that clastic pulse to the basin may represent the direct environmental response of the SPFB sedimentary routing system to hyperthermal events during EECO, and that hyperthermal events M to P may be recorded in the stratigraphy.

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Poster presentation

Provenance, chemical weathering, and climatic changes in the Variscan foreland basin: insight from geochemical records in Mississippian to Pennsylvanian Namurian Shale, Belgium and S-Netherlands

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The Late Paleozoic Ice Age is characterized by multiple glacial stages alternating with non-glacial or weak glaciated stages across the Gondwanan supercontinent. During this time interval, Mississippian to Pennsylvanian shale play was widespread in the Variscan Foreland Basin across Europe. To evaluate the impact of climate on the depositional environment in the Variscan Foreland Basin, a geochemical study of 10 major element oxides, total sulfur content, and 13 trace elements was carried out on a large sample set in five wells from the Namurian Shale in the Namur Synclinorium and Campine Basin in Belgium and the southern Netherlands. In terms of the correlations between elements, minerals, and organic matter, these elements were categorized into six groups based on their different geochemical behaviors. Major and trace elements in the group related to detrital influx were analyzed to reconstruct the provenance and effects of climate, using a combination of multiple weathering indices. To avoid misinterpretation of weathering indices, four non-weathering factors (provenance, diagenesis, sedimentary recycling, hydraulic sorting) were evaluated. Namurian A mudstones were derived from broadly similar provenance mainly from intermediate igneous rocks in a continental island arc setting. The impact of provenance, diagenesis, mineral sorting, and grain size differentiation on weathering indices is relatively minor while sedimentary recycling appears to be a probable occurrence, especially in the Namur Synclinorium. A general warm and humid climate with occasional hot and humid climate existed during the Namurian A stage. The stratigraphic distribution of weathering indices represents a general increase in temperature and humidity from the early to late Namurian A stage. Moderate chemical weathering occurred in the Campine Basin and the western Namur Synclinorium, which had lower average annual precipitation and temperature compared to the eastern Namur Synclinorium, which experienced moderate to intense weathering intensity with higher annual averages for precipitation and temperature.

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Special Session 12.6. Paleosols as valuable records of terrestrial climate and environments

Oral presentation

Redox geochemistry and the origin of red colouration in palaeo-vertisols of the Old Red Sandstone, South Wales, UK

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Starting with the Great Oxidation Event 2.2 Ga and deposition of the Hekpoort laterite paleosol, Botswana, continental red beds (CRB) are considered intriguing archives of interactions between oxic atmosphere and lithosphere. CRBs have been regarded as products of early diagenetic release of Fe(II) from primary silicates, its oxidation to goethite and subsequent dehydration to hematite under hot, arid continental climates. The abundance of CRB in early Devonian, Permian, and Triassic times suggest they may represent time-specific facies of palaeoclimatologic significance. However, CRB may encompass a broad spectrum of contrasting palaeoenvironments, including intermittently water-logged palaeo-Vertisols. Redox processes are crucial in the formation of CRB while they can take place in different environments and variable free oxygen contents. In this presentation, we will combine the redox geochemistry of palaeo-Vertisols of the Devonian Old Red Sandstone (ORS), with quantitative representation of the sediment colour and mineralogy of the Fe-bearing phases. High-resolution (5 to 10 cm) sampling of three coastal sections of ORS from South Wales, UK, has been combined with facies analysis, bulk-rock geochemistry (X-ray fluorescence combined with ICP MS), diffuse reflectance spectroscopy, X-ray diffractometry, and Mossbauer spectroscopy applied to bulk-rock samples. Mineralogy and in-situ geochemistry of redox-sensitive elements, Fe, Mn, As, Cu, U, Mo, V, and rare earth elements have been studied by reflected-light optical microscopy, electron microprobe analysis and laser-ablation ICP-MS. Various diagenetic and pedogenic features including bioturbations, fracturing in Vertisols, mudcracks, calcretes, reduction haloes, their diagenetic sequence, stratigraphic context, and in-situ redox geochemistry will be presented with an aim to elucidate the timing and redox conditions of the pedogenic red colouration in this classical example of CRBs.

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Oral presentation

Base level variations recorded in Holocenic alluvium succession of mountain area of SE Brazil: climate and anthropic control

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Holocenic alluvium sedimentary successions constitute a significant record of the recent history of Earth. This research considers a Holocenic alluvial sedimentary succession of very fine-grained sand, c. 4 m thick, located in the Serra do Espinhaço (SE Brazil), in a flat area of 2.4 km^2, surrounded by Mesoproterozoic quartzarenite mountains. The aim of this research is to reconstruct the succession of geological events recorded by these alluvial deposits and relate them to palaeolandscape variations and their controlling factors. Macroscopic, micromorphological and geochemical analyses, and C^{14} dating of the alluvial succession allowed recognising five geological intervals. From bottom to top: (i) First interval, dated 7401±33 yBP, consists of sand with more than 12% of organic carbon and fossil tree stumps in living position. It represents a Histosol formed in a swamp with groundwater close to the topographic surface. (ii) The second interval is constituted of c. 1.5 m of interlayered white and dark grey sands. Subcritical climbing ripples and planar parallel laminations indicate unconfined paroxysmal alluvial flow deposition. (iii) A Spodosol (A–E–Bh–Bs–C), c. 1.5 m thick and dated 1589±27 yBP, follows. E is eluviated horizon, Bh shows illuviated organic matter and Bs Fe-hydroxides accumulation. This palaeosols indicates acid and seasonally drained conditions. Empirical equations, based on molecular weathering ratio, suggest annual precipitation c. 1300 mm/y, similar to today. (iv) The fourth interval is 0.3 m thick and consists of white sands with small ripples and planar laminations deposited by unconfined flows. (v) Finally this succession is cut by present-day erosion. The first and third intervals testify pedogenesis and stability of the landscape in humid climate, though less humid and drained conditions characterise the third interval. The second and fourth intervals were characterised by extreme precipitation events probably in drier climate conditions. The last interval testifies an abrupt dropping of the base level (the ground water). Climate variation can be ruled out because the annual precipitation is analogous with the third interval. This last dramatic phase of erosion is probably linked to the intense deforestation that this area underwent starting from 18th century.

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Oral presentation

Evidence of Late Quaternary environmental changes preserved within the Privlaka pedo-sedimentary complex at the eastern Adriatic coast, Croatia

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The Privlaka pedo-sedimentary succession (Eastern Adriatic coast, Croatia) is a promising archive of palaeoenvironmental changes as it shows a clear alternation of (a) palaeosol(s) and glacio-fluvial deposits. The objective of this study is to describe the palaeosols and sediments, and unravel the nature, magnitude and timing of environmental change preserved within this terrestrial record. To this end, a more than 12 m thick section was investigated in detail, which is divided into four different units of which one is represented by a reddish palaeosol, and the other three by sediment packages, each indicating a different pedosedimentological context. For the purpose of delineating the absolute thickness and lateral extent of the complex, geoelectrical soundings and remote sensing techniques were deployed. The profile was thoroughly described and sampled for the purpose of conducting high-resolution palaeoenvironmental research using mineralogical, geochemical, pedophysical and micromorphological properties. Preliminary results will be presented and discussed in the light of the Late Quaternary palaeoenvironmental evolution of the region and surroundings.

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Oral presentation

"It's a trap!" – critical assessment of geochemistry-based proxies in reconstructing past environments

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Inorganic geochemical data are commonly used in various palaeoenvironmental studies of marine and continental sedimentary sequences, especially for reconstructing paleoclimatic or palaeosalinity conditions or for provenance studies. This stems from the fact that geochemical methods are relatively fast, cheap, and fairly robust. However, despite numerous studies highlighting weak points of the geochemical analysis in sedimentary geology, common palaeoenvironmental proxies, such as boron-based paleosalinity indices, CIA, CIW etc., are used without wider environmental considerations. Often geochemical data are not compared with mineralogical or sedimentological data. The interpretations of such data are commonly doubtful and can provide a false picture of past environments.

To understand what controls the geochemical composition of mudstones, we performed a study based on over 500 samples obtained from numerous sedimentary basins of various ages but with a relatively low degree of diagenesis. The sample set included the Ediacaran/Cambrian samples from the East European Craton, the Carboniferous samples from Donbas Basin (Ukraine), Permian, Lower and Upper Triassic mudstones and palaeosols from Poland, and Miocene molasse mudstones and sandstones from Poland. Geochemical data were compared with quantitative bulk rock and clay fraction mineralogy, as well as with sedimentological data. Our mineralogical and geochemical analyses indicate that the elements commonly used in the palaeoenvironmental reconstructions, such as K, B, Ga, Rb, and Cs, are mainly controlled by the relative amounts of K-feldspar, micas, and illite–smectite (B and Ga also by kaolinite and hematite), thus detrital, weathering and late diagenetic mineral components, and not syn-sedimentary components. These apparent geochemical–mineralogical relationships cannot be translated into past environmental conditions.

Our study proposes a more appropriate strategy for reconstructing past sedimentary environments, which should combine all possible data instead of using the geochemical data separately.

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Oral presentation

Late Miocene to Pliocene rise and fall of C4 vegetation in Anatolia (Türkiye)

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Following 2.8 billion years of dominance of the C3 photosynthetic pathway, C4 vegetation rapidly rose to ecological dominance between 8 and 3 Ma. C4 vegetation, of which 60% consists of grasses, fares well under conditions of drought, high temperature, and low atmospheric CO_2. C4 vegetation is presently ecologically dominant in vast parts of the world's grasslands, including eastern South America, sub-Saharan Africa, and South Asia, and associated with warm season precipitation. To this date, the percentage of C4 grasslands is limited in Europe and western Asia. To reconstruct the presence of C4 vegetation in the Eastern Mediterranean region we present the first comprehensive Late Miocene to recent soil carbonate $\delta^{13}C$ compilation (Anatolia, Türkiye and the Aegean, Greece). Soil carbonate $\delta^{13}C$ records enable discerning between C3 and C4 vegetation, given that C4 vegetation typically yields $\delta^{13}C$ values ca. 14 ‰ more positive than C3 vegetation. Our new results (fifteen sites, n = 447) from Anatolia show a shift from mixed C3–C4 vegetation at 9.9 Ma (average $\delta^{13}C$ = -5.2 ‰) to dominant C4 vegetation between ca. 9.9 Ma and 7.1 Ma (average $\delta^{13}C$ = -1.2 ‰). The relatively high $\delta^{13}C$ values in our new Anatolian and published Aegean records as early as 9.9 Ma indicate that C4 vegetation colonized Anatolia and the Aegean simultaneously with northwest and east Africa. The subsequent shift to dominance of C4 vegetation in Anatolia is in line with vegetation records from South Asia, with their common driver likely being the decrease in pCO_2 and increased aridity during the Late Miocene. The Anatolian $\delta^{13}C$ soil carbonate data are unique in that a subsequent reversal and permanent return to C3 dominance occurs between 4.9 and 3.9 Ma, with $\delta^{13}C$ values averaging -7.8 ‰ until today. This Early Pliocene drop in $\delta^{13}C$ values occurs synchronously with the demise of C4 grasslands and the open environment-adapted large-mammal Pikermian chronofauna in Anatolia, as well as a drop in mean cold month temperatures. We conclude that paleoclimatic processes and potentially surface uplift affected rapid and large–magnitude floral and faunal shifts. Ultimately, we hypothesize these effects induced a switch from warm season precipitation to cold season precipitation which resulted in the demise of C4 vegetation at the European–African–Asian crossroads.

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Oral presentation

Medieval climatic optimum recorded by buried podzols: a new pedostratigraphic marker in inland dune deposits of Poland

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Palaeosols preserved in the aeolian dunes of the eastern European Sand Belt are mostly Arenosols or rarely Podzols. The study aims to document the occurrences of buried Podzols recognized in ten inland dune sites scattered in Eastern and Central Poland. Based on uniform age, palaeosol properties and geomorphologic setting, the new pedostratigraphic marker is proposed and named Grębociny soil, after the type locality. The fieldwork comprised sedimentological and pedological documentation in the sand pits. Palaeosol samples were subjected to laboratory analyses of grain size distribution, carbon and nitrogen content, and pH. The age determination was based on the ^{14}C dating of charcoals. In all ten sites, podzolic palaeosols are buried by sand layers of thickness ranging from tens of centimetres to 2 m. Palaeosols display proper eluvial and illuvial horizons, which together with measured pedological properties allow them to be classified as Podzols sensu stricto. In four sites, structures interpreted as cattle hoofprints occur on the top surface of the palaeosol. The calibrated radiocarbon ages of all studied Podzols are within the 5th–15th century AD range of historical Middle Ages. Prevalent podzolization during the Middle Ages could be facilitated by agriculture and forestry, but also relative warmth and humidity of the Medieval Climatic Optimum. In turn, widespread soil preservation was enabled by burial during anthropogenically induced dune remobilization. Well-documented Medieval Podzol occurrences meet the criteria of a reliable pedostratigraphic marker. Therefore, it is proposed that the Grębociny soil is established as a new marker horizon in the dune deposits of the eastern European Sand Belt.

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Oral presentation

Glauconite formation in a palaeosol as an indicator of the incipient sea-level rise: case study of the Zlatni rt, Istria, Croatia

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Glauconite is usually found as a replacement of bioclasts and faecal pellets through neoformation and replacement of iron rich smectite in deepwater environments on the shelf-slope break. In the last two decades the formation of glauconite in shallow water environments was progressively recognized and utilized in palaeoenvironmental reconstructions. The Lower Kimmeridgian to Late Tithonian Zlatni rt (ZR) clay is one of the examples of glauconite formation in shallow water environment and a rare example of glauconite formation from a palaeosol. The ZR clay occurrence represents a decimetre thick horizon of grey clay embedding the black pebbles. The clay is also present as infills in the karstified bedrock, in which the glauconite is present within the contact zone of the clay and bedrock. The clay is primarily composed from mixed-layered illite–smectite, $2M_1$ illite, kaolinite, vermiculite, pyrite, marcasite and titanium oxides. The clay itself can be identified as a palaeosol which formed in contact with the marine environment, indicated by the high Sr/Ba ratios and enrichment of heavy rare earth elements and a slight negative cerium anomaly. The presence of glauconite was confirmed by SEM-EDS, XRPD and FTIR. The glauconite formed mainly through the fixation of potassium and iron into illite and illite–smectite, but there is also strong evidence of its neoformation through bacterially mediated dissolution of present phyllosilicates. The source of iron was most likely terrigenous, as there is evidence for a ferralitic input through the presence of kaolinite in the ZR clay. Glauconite is also present in a more reduced form and as a more oxidized form, which display an alternation with pyrite in veins. This reflects the oscillations in the redox potential during glauconite formation, which can be linked to the variations in water column depth during the initial stages of the transgression. The final drowning of the ZR clay is recorded with the precipitation of coarse euhedral pyrite, during which the deposition of lagoonal Upper Tithonian Kirmenjak limestones had started.

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Oral presentation

Paleosols in the Triassic Yanchang Formation, Ordos Basin, China

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Paleosols are very important paleoclimatic indicators. During the Middle–Late Triassic, the Ordos Basin in China was a huge continental basin characterized by a permanent lacustrine body surrounded by different related continental deposits. Stratigraphic evidence suggest that the size of this lake experienced large fluctuation driven by climatic cycles. These fluctuations in the lake level result in the common occurrence of edaphic horizons at different stratigraphic levels. During recent years, a new detailed field study was conducted on outcrops of the Yanchang Formation located close to the West margin of the basin (Yanhe and Shiwanghe sections). As a result, a new composed stratigraphic column was measured and analyzed in detail. Along a stratigraphic column of more than 1,000 meters several paleosols levels have been recognized. From base to top, these paleosols show marked differences evidencing an origin linked to progressively changing paleoclimatic conditions. In the lower section (Chang 10–9) most paleosols are reddish to yellow colored with sparse root traces and caliche nodules. According to this, these paleosols are interpreted as originated in an arid environment. From the upper part of Chang 9 and upwards (Chang 8 and 7) the paleosols are gray colored and show abundant black roots. This change is related to an origin in a semiarid–semihumid environment. In the upper part of the section (Chang 6–2) the paleosols are brown-yellowish colored, and show sparse little root traces. From these evidences arid to semiarid conditions are interpreted for the considered interval. Finally, in the uppermost part of the section (Chang1) the paleosols commonly show coal levels, evidencing semiarid to semihumid conditions. The arid environment paleosols in Yanchang Formation often show an exceptional preservation of in situ (erected) large trees, immersed in massive fine-grained sandstones. These fossil trees are interpreted as preserved by catastrophic flood events.

Theme 12. Stratigraphic markers and archives

Special Session 12.6. Paleosols as valuable records of terrestrial climate and environments

Poster presentation

Redoximorphic features in paleosols in Plio-Quaternary alluvial deposits in Slovenske Gorice, Western Pannonian Basin, Slovenia

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Extensive construction works for the motorway sections in northeastern Slovenia during the past two decades exposed large continuous outcrops of alluvial and lacustrine deposits of the western part of the Pannonian basin. Plio-Quaternary alluvial successions in the studied area are predominantly composed of facies associations corresponding to channel and floodplain environments and contain prominent paleosols. Pedogenically modified deposits are distinguished by a variety of macrofeatures characteristic of hydric and reduced soils. Paleosols are macroscopically recognisable by their distinctive colour patterns, which were mostly formed by reduction, oxidation and relocation of Fe and Mn compounds in water-saturated and chemically reduced soils. This study has focused on recognition, classification and interpretation of Fe/Mn-based macro- and micromorphological features in order to reconstruct environmental conditions during the soil formation. Redoximorphic paleosol features were studied in 44 sections along the motorway road-cuts. Paleosols are developed on non-calcareous parent material, composed of non-cemented siliciclastic gravel, sand and silt/clay. Macroscopically, three main groups of features have been identified: 1) redox concentrations (Fe–Mn oxides in form of non-cemented masses, pore linings, concretions and nodules), 2) redox depletions (zones of Fe and/or clay depletions along the pores and in the matrix), and 3) reduced soil matrices. Whereas the general appearance of horizons in the studied paleosols is controlled by either high-chroma redox concentrations (reddish Fe oxide coatings on mineral grains and impregnation of the groundmass) or low-chroma reduced soil matrix, contrasted colour patterns largely correspond to redox and clay depletions and/or concentrations along individual root voids and branched root systems. Although generally not macroscopically discernable, microscopic observation indicates that horizontally spreading systems of fine roots appear to be the main control also in formation of typical banded, zebra-like redoximorphic patterns. Co-occurrence of root-related features indicative of contradicting redox conditions shows that thick paleosol profiles probably correspond to multiple stages of hydric soil formation.

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Special Session 12.6. Paleosols as valuable records of terrestrial climate and environments

Poster presentation

Does a change in hydrological conditions impact mineralogy and chemistry of Pennsylvanian paleosols from the Upper Silesia Coal Basin (Poland)? Preliminary results

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The Pennsylvanian coal-bearing continental succession of the Upper Silesia Coal Basin (USCB) serves as an excellent laboratory to test hypothesis related to climatic control of the basin fill. About 8 km thick succession contains hundreds of the paleosols developed within alluvial valleys constructed by braided and meandering fluvial systems. Irrespective of the type of fluvial system, mature paleosols are observed only in the youngest part of the basin fill. This study investigates a series of paleosols from the two youngest units of the USCB i.e. Mudstone Series and Krakow Sandstone Series. Paleosols are materials that have been in a direct contact with surface conditions at certain point in time. Paleosols have, therefore, a high potential to record environmental conditions prevailing during their formation. Previous studies suggested that deposition of Krakow Sandstone Series was dominated by braided river systems and deposition of Mudstone Series by meandering river systems. Paleosols associated with both series differ significantly in thickness and maturity, both being greater for Krakow Sandstone Series. Due to the differences in thickness of paleosols it is speculated that hydrological conditions differed. The aim of this study was to investigate if the difference in hydrological conditions was recorded by mineralogical and chemical composition of paleosols coming from both series.

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Special Session 12.6. Paleosols as valuable records of terrestrial climate and environments

Poster presentation

Paleoenvironmental and paleoclimatic changes during the deposition of Upper Jurassic bauxites and their immediate cover: case study of the Rovinj bauxite pit, Istria, Croatia

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The aim of this study was the reconstruction of paleoclimatic and paleoenvironmental changes which occurred during the deposition of Upper Jurassic bauxite, and their cover beds, which comprise a cyclic alternation of clays, limestones, and black pebble breccias. Clay and bulk mineralogy, geochemistry and micromorphology of bauxites and clays was studied using XRPD, SEM-EDS, ICP-MS, XRF, AAS and petrography. The bauxite is composed from haematite, boehmite and kaolinite with variable amounts of 14 Å clay, illite and titanium oxides. The composition of major oxides is consistent with the mineralogical composition and is uniform throughout the profile. The values of rare earth elements and variations in the trace element values displayed differences throughout the bauxite profile, distinguishing two bauxite sections, both capped by two clay illuviation rich horizons. The upper section has numerous erosional features and clastic bauxite beds, which when coupled with its different trace elemental fingerprint indicates its deposition over the older pelitomorphic section. This change is likely a consequence of a paleoclimatic shift towards a more seasonal climate during the formation of the younger part of the bauxite. This can be related to the oscillating transgression succeeding the bauxite formation, which is recorded in the cyclical beds covering the bauxite. The clays from the cover beds are composed from dioctahedral vermiculite, kaolinite, illite and a mixed-layer clay mineral (MLCM) consisting of illite and dioctahedral 14 Å phyllosilicate. The increase in illite and MLCM over kaolinite and the increase in Sr/Ba ratio along the profile, indicate a change from a lacustrine towards a marine environment. The iron speciation data supports this, as it recorded the redox changes which indicate a transition from a closed lacustrine environment to an open marine environment. Overall, the study of both bauxites and their cover, allowed a detailed reconstruction of a late Kimmeridgian transgression that followed a terrestrial phase in this part of the Adriatic carbonate platform.

This work has been fully supported by Croatian Science Foundation under the project IP-2019-04-8054 – WianLab (Western Istrian Anticline as an Ideal Natural Laboratory for the Study of the Regional Unconformities in Carbonate Rocks).

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Special Session 12.7. IGCP739: The Mesozoic–Paleogene hyperthermal events

Oral presentation

Mercury and tellurium anomalies reflect increased volcanism during the Paleocene–Eocene Thermal Maximum (PETM)

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The Palaeogene represents the last "greenhouse" period characterized by high atmospheric CO_2 concentrations and warm surface temperatures. Several transient hyperthermal events punctuated this long-term climatic state. These events are recorded primarily by prominent negative Carbon Isotope Excursions (NCIE) in carbonates of sedimentary successions. The largest hyperthermal of the Palaeogene, the Palaeocene–Eocene Thermal Maximum (PETM), is associated with a 5–8° rise in global temperature, ocean acidification, and a global biotic perturbation. The PETM is thus often seen as a geological analog for future greenhouse-gas-driven global warming. The source of the ^{13}C-depleted carbon for the NCIE remains controversial. Numerous carbon sources have been suggested, either in concert or individually, to explain the onset and duration of the NCIE. These include the magmatic and thermogenic release of CO_2 associated with large-scale magmatism. Over the last decade, mercury (Hg), and more recently tellurium (Te) anomalies found in marine and continental sedimentary succession have proven to be excellent tracers of past volcanism emissions, to track the connection between the development of the large igneous provinces (LIPs) and periods of warming, mass extinctions, and biotic disturbances. We present a comprehensive high-resolution Hg data from a transect including 11 PETM sections deposited in continental, shallow and deep environments from Fur (Denmark), Zumaya, Lussagnet, Campo, Esplugafreda (Spain), Dababiya, Wadi Nukhul and Beida (Egypt), and Aktumusk, Kaurtaukapi, Aktash (Uzbekistan). So far, tellurium has been measured only in the Danish and Egyptian sections. We find that the PETM interval is consistently associated with significant Hg and Te anomalies regardless of the depositional environment. These results suggest that large pulses of volcanism, probably related to the emplacement of the North Atlantic Igneous Province, contributed to the onset and possibly also the long duration of the PETM.

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Special Session 12.7. IGCP739: The Mesozoic–Paleogene hyperthermal events

Oral presentation

Geochemical and palaeontological fingerprints of mixed clastic–carbonate successions from the Transdanubian Range (Hungary, Central Europe) during the Carnian Pluvial Episode (Late Triassic)

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The Upper Triassic succession of the Transdanubian Range (TR) is a valuable sedimentary archive of Mesozoic climatic and environmental perturbations. The TR was located between the Northern Calcareous Alps and the Southern Alps during the Mesozoic. Over the Western Tethys, the Carnian sedimentary successions record an increase in clastic input to the carbonate-dominated marine environment due to the intensification of greenhouse conditions, global warming and acceleration of the hydrological cycle, called Carnian Pluvial Episode (CPE). The global-scale environmental changes are associated with significant volcanism and carbon cycle perturbation, as evidenced by multiple negative carbon isotope excursions (NCIE) in the Julian 2–Tuvalian, followed by biotic turnover on land and in the oceans. The CPE manifests in the TR as a switch from pelagic basin and platform carbonates to the deposition of a mixed clastic–carbonate sediments in intraplatform basins. Previous clay mineral data from the TR have confirmed changes in the rate of continental hydrolysis and weathering but detailed records that constrain the complex biogeochemical phenomena across the CPE such as nutrient cycling or redox conditions are still lacking. Here we investigated the geochemical and palaeontological fingerprints of the CPE from two drilled core successions (Balatonfüred-1, Veszprém-1) using major and trace element analysis integrated with organic carbon isotope analysis, palynological, and ostracod data. Julian ostracod assemblages in the TR are impoverished due to terrestrial and freshwater influx while palynological assemblages record stepwise increase in hygrophytic plants during the Julian 2. The first NCIE in the Julian 1–2 transition precedes the increase in siliciclastic input and is associated with pronounced fluctuations in detrital influx (Ti, Zr, Si), productivity (P, Ba) and redox proxies (V, Ni, U). At the same time, the increase in kaolinite/illite ratios and weathering proxies (αS, αBa) in the early Julian 2 suggests that the enhanced runoff provided at least temporarily, high amounts of nutrients leading to a short-term boost in productivity and thermohaline stratification within the relatively small intraplatform basins during the NCIE based on a slight enrichment in redox-sensitive trace elements.

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Special Session 12.7. IGCP739: The Mesozoic–Paleogene hyperthermal events

Oral presentation

Palaeoenvironmental records across the early Toarcian hyperthermal event: from onset to recovery

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Earth's climate history has been punctuated by many episodes of extreme climate change that were often associated with fast fluctuations in atmospheric greenhouse gas levels. Such coincidence proves a strong feedback link between the climate and the carbon cycle. The Toarcian Oceanic Anoxic Event (T-OAE, ca. 183 Ma) was one of the most extreme hyperthermal events of the Phanerozoic associated with the massive input of carbon into the ocean–atmosphere system and accompanied by major environmental changes. The causes and consequences of this global-change event are relatively well constrained, but how the Earth's climate system naturally stabilized and recovered remains largely understudied. In particular, constraints on the carbon feedback mechanisms that amplified or suppressed climate change, their timing, and their fluxes are needed to determine Earth's sensitivity to changing climate conditions. In this communication, we will present a new multi-proxy dataset combining sedimentological observations and mineralogical and geochemical analyses performed on worldwide distributed T-OAE sedimentary successions from France, Morocco, Siberia, and Chile. The correlation of the studied sites is based on the new high-resolution carbon isotope stratigraphy. Emphasis was given to exploring the evolution of the two feedback mechanisms considered central in the stabilization and recovery of the carbon cycle-climate system: (1) weathering of continental silicates and (2) burial of organic carbon. Lithium isotope ratios are used to proxy of global weathering rates and reveal that higher silicate weathering rates during the Toarcian hyperthermal likely helped the climate system recover and return to cooler climatic conditions. High mercury and tellurium concentrations recorded after the T-OAE interval suggest that protracted Karoo–Ferrar volcanic activity may have impacted the feedback mechanisms and hence played a role in the response of Earth's climate. This study offers quantitative input to have a holistic understanding of how biogeochemical cycles have controlled Earth's carbon cycle-climate dynamics over geological time scales.

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Oral presentation

Enhanced chemical weathering during the Carnian Pluvial Episode in the Southern Alps (northern Italy)

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The Carnian Pluvial Episode (CPE) was a global climate and biological crisis that occurred in the early Late Triassic (~232–234 Ma), and has been linked to C-cycle perturbations and global warming. In the Western Tethys, the CPE is marked by the demise of high-relief carbonate platforms and the deposition of thick siliciclastic successions. To better understand the mechanisms that controlled siliciclastic deposition in the area, and the relationship between physical-chemical weathering processes and the CPE, a study on clay minerals and geochemistry has been carried on the Carnian succession of the Dolomites (northern Italy). Major, minor and trace elements, and mineralogical composition have been analyzed in fine-grained sediments. The quantitative mineralogical composition was obtained from whole-rock XRD analysis using the Rietveld method. Identification of clay minerals was performed on oriented mounts of the <2μm fraction. Results show that, among the clay minerals, the predominant phase is represented by interstratified illite/smectite. An enrichment in the content of kaolinite and illite is observed in the stratigraphic interval encompassing the first C-isotope excursion of the CPE. This mineralogical change is not linked to changes in sediment-source or depositional setting. Hence, the results indicate an intensification of the hydrological cycle and chemical weathering during the initial phase of the CPE (first negative C-isotope shift), as also shown by a coeval parallel increase of CPA and Rb/K_2O weathering indices. After this first phase, a decoupling between CPA and Rb/K_2O is interpreted as the effect of a major sea level fall, which caused strong erosion and recycling of Middle Triassic volcanic rocks, and a substantial increase of K-feldspar delivered to the basin. Data from the overlying, post-CPE Travenanzes Fm show high physical weathering under arid climate.

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Oral presentation

Spatially heterogenous seawater $\delta^{34}S$ and global cessation of gypsum deposition during the Toarcian

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The processes and mechanisms behind widespread ocean deoxygenation associated with the Toarcian Oceanic Anoxic Event (T-OAE, ~183 Ma) are unclear. Here, we utilize high-resolution carbonate-associated sulfate-sulfur isotope ($\delta^{34}S_{CAS}$) analyses from sedimentary successions of the eastern Tethys (Tibetan Himalaya) to document a large positive sulfur-isotope excursion (SIE) from ~20‰ to ~40‰ in the early Toarcian. Importantly, our results show that high $\delta^{34}S_{CAS}$ values were maintained into the mid-late Toarcian, even when global anoxic conditions diminished. The $\delta^{34}S$ data confirm significant spatial heterogeneity in seawater $\delta^{34}S$ compositions during the T-OAE, and provide strong evidence for a two-phase pattern of ocean deoxygenation and upwelling of ^{34}S-enriched equatorial deep water (major pyrite burial) that likely caused the greatly amplified Tibetan SIE. Box modelling results indicate that the persistent post-T-OAE positive $\delta^{34}S$ values were likely maintained because of a global reduction in gypsum burial during and after the T-OAE, driven by declining seawater sulfate concentrations.

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Special Session 12.7. IGCP739: The Mesozoic–Paleogene hyperthermal events

Oral presentation

Marine redox dynamics in the European epicontinental sea during the end-Triassic mass extinction

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The end-Triassic mass extinction (ETME) was associated with extensive marine anoxia driven by Central Atlantic Magmatic Province activity and hyperthermal conditions. However, the temporal and spatial changes of marine redox conditions in the western Tethys and their links with biotic turnovers have not been fully explored. Here, we report carbon and nitrogen isotopes, iron speciation and redox-sensitive trace metal data through a continuous siliciclastic borehole (Dove's Nest) from the Cleveland Basin, NE England (~201 Ma). Results show periods with frequent anoxic-ferruginous or euxinic conditions through the late Triassic (Westbury Formation) and across the Triassic–Jurassic (T–J) boundary. However, commonly oxic conditions dominated the basin during the deposition of Cotham Member and across the first phase of the ETME, in stark contrast to pervasive anoxia elsewhere in the European epicontinental sea. Other environmental stressors, rather than oxygen depletion, may have led to the initial phase of the biotic crisis. Over the entire T–J transition, geochemical evidence for frequent water column anoxia from many North Hemisphere basins, combined with the evidence of benthic colonization on the seafloor, demonstrate that the wider epicontinental sea was poised in an unstable oscillating redox state. Redox conditions fluctuate both in time and space with the limited geographic spread of anoxia and thus limited stress on the benthic ecosystem at the beginning of the ETME.

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Special Session 12.7. IGCP739: The Mesozoic–Paleogene hyperthermal events

Keynote lecture

Mesozoic and Cenozoic hyperthermal events and Anthropocene global warming

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A deeper understanding of hyperthermal events in the Earth's history can provide an important scientific basis for understanding and coping with global warming in the Anthropocene. Two types of hyperthermal events are classified based on the characteristics of the carbon isotope excursion (CIE) of the representative hyperthermal events in the Mesozoic and Cenozoic. The negative CIEs (NCHE) were represented by the Permian–Triassic boundary event (PTB, ~252 Ma), Triassic–Jurassic boundary event (TJB), the early Toarcian oceanic anoxic event (TOAE, ~183 Ma), and the Paleocene–Eocene Thermal Maximum event (PETM, ~56 Ma). The positive CIEs (PCHE) were represented by the early Aptian oceanic anoxic event (OAE1a, ~120 Ma) and the latest Cenomanian oceanic anoxic event (OAE2, ~94 Ma). Hyperthermal events of negative CIEs (NCHE), lead to dramatic changes in temperature, sedimentation, and biodiversity. These events caused frequent occurrence of terrestrial wildfires, extreme droughts, acid rain, destruction of ozone layer, metal poisoning (such as mercury), changes in terrestrial water system, and carbonate platform demise, ocean acidification, ocean anoxia in marine settings, and various degree extinction of terrestrial and marine life, especially in shallow marine. In contrast, hyperthermal events of positive CIEs (PCHE), result in rapid warming of seawater and widespread oceanic anoxia, large-scale burial of organic matter and associated black shale deposition, which exerted more significant impacts on deep-water marine life, but little impacts on shallow sea and terrestrial life. A comparative study of the onset of the two types of hyperthermal events reveals that the characteristics of Anthropocene global warming are similar to those of the NCHE-type hyperthermal events, with higher warming rates, carbon isotope excursion rates, and carbon emission rates than those of the onset of the NCHE-type hyperthermal events in Mesozoic–Cenozoic. If the present warming trend continues, the Earth is likely to experience environmental consequences similar to those of the PETM and PTB events on the century–millennium scale.

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Oral presentation

Volcanism as trigger of Sinemurian/Pliensbachian environmental changes? Evidence from Lower Jurassic marine (Western Tethys, Italy) and continental (Sichuan Basin, China) successions

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The Sinemurian–Pliensbachian transition in the Early Jurassic is characterized by a negative perturbation of the global carbon cycle named "Sinemurian–Pliensbachian Boundary Event" (SPBE, ~192.5 Ma). The SPBE is associated with sedimentological evidence of environmental and climate changes such as increased runoff, modifications in marine shallow water carbonate production, enhanced preservation of organic matter, dysoxic conditions in the oceans end possible hyperthermal intervals. The SPBE has been mainly reported in the marine realm, while other sedimentary settings around the world has been less investigated, and its causes are still unclear. This study reports records of mercury abundance and other geochemical data (TOC, δ^{13}Corg, Δ^{199}Hg, Δ^{202}Hg) from two stratigraphic sections from the continental succession of the Sichuan Basin (Eastern Tethys) and the deep marine Lombardian Basin (Western Tethys). δ^{13}Corg Results allow refining global scale correlations with other marine records and highlight that the SPBE time is characterized by Hg enrichments both in continental and marine realms. The relative low correlation of Hg content with TOC data and the clay minerals abundances, points to a volcanogenic source of the mercury. This is further confirmed by Δ^{199}Hg, Δ^{202}Hg data. The fact that mercury enrichments are seen both in the continental and the marine deep-water sedimentary record, strengthen the global significance of the environmental changes occurred at the SPBE and point to enhanced volcanism as their primary driver, calling for further investigations to identify where such volcanic activity was taking place.

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Oral presentation

Eustatic variations across the Paleocene–Eocene Thermal Maximum in the epicontinental Tarim seaway

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The Paleocene–Eocene thermal maximum (PETM) arguably offers the best analogy to study the ecological and environmental response to the ongoing global warming. Sea-level changes during the PETM remain poorly constrained. This study illustrates stratigraphic and sedimentological evidence, high-resolution microfacies and carbon-isotope analysis of the PETM interval from the epicontinental Tarim seaway. The negative carbon isotope excursion precisely constrains the stratigraphic position of the PETM event within the Qimugen Formation. Microfacies data show that tidal and lagoonal environments presenting in the Tarim seaway during the pre-PETM stage were gradually replaced by open-marine middle-ramp marlstones at the PETM onset, overlain in turn by outer-ramp pelites in the syn-PETM stage, and eventually by middle-ramp carbonates in the post-PETM stage. The transgressive sequence reveals a deepening of paleo-water depths from the coast before the PETM to a maximum flooding below the storm wave base (around 20–30 m) during the peak of the PETM. This is further evidenced by the relative content of planktonic foraminifera to total foraminifera (40–80%), which corresponds to a minimum paleo-water depth of 30–50 m. Regional and global comparisons of sea-level changes suggest that the about 20–50-m sea level rise documented in the Tarim epicontinental seaway chiefly represents a eustatic signal associated with diverse mechanisms associated with warming climate.

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Oral presentation

The Carnian pluvial episode in China: tracing its origins, challenges, and perspectives

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The Carnian Pluvial Episode (CPE) is a remarkable episode of climate change that took place around 234 Ma in the Late Triassic. During the CPE, the humid weather and subsequent increase in runoff led to the influx of coarser clastic sediments in the Tethys, resulting in a sharp change in shallow carbonate factories. In addition to changes in sedimentation, the CPE is also characterized by the presence of dysaerobic to anoxic conditions in basinal settings and a biotic turnover or extinction. The CPE is also patterned by multiple negative shifts in carbon isotopes, the first one marking its onset. Massive CO_2 injection has been attributed to the eruption of the Wrangellia Large Igneous Province. This hypothesis is supported by enrichment of volcanogenic Hg and increased influx of unradiogenic Os. The CPE has been well studied in the western Tethys, and there is also evidence of this event in China, with records spanning from terrestrial to marine settings. The CPE was first reported as the Carnian Black Shale Event due to the demise of the Carnian platform and the subsequent deposition of black shale in Western Sichuan Basin. Since then, numerous studies have been dedicated to investigating changes in sedimentation patterns, redox conditions, biotic assemblages, carbon isotopic composition, that occurred during the CPE in China. However, debates regarding the CPE still exist, particularly concerning the age determination of the event in the lake Ordos Basin and Western Sichuan Basin, as well as the inconsistency in the trends of carbon isotopes from carbonates and organic matter. Nevertheless, China offers promising locations for studying the CPE, as it records continuous Carnian successions across different environmental settings. By investigating these successions, researchers can gain valuable insights into the CPE and its impacts in the eastern Tethys.

Theme 12. Stratigraphic markers and archives

Special Session 12.7. IGCP739: The Mesozoic–Paleogene hyperthermal events

Oral presentation

Spatial heterogeneity in carbonate-platform environments across the Paleocene–Eocene Thermal Maximum in eastern Tethys

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The Paleocene–Eocene Thermal Maximum (PETM, ~56 Ma) is a large negative carbon isotope excursion (CIE) that testifies to a massive perturbation of the global carbon cycle and has been considered to be the best ancient analogue for present climate change and global warming. However, the environmental response to the PETM in shallow-water carbonate platforms has remained largely elusive. This study presents new sedimentological, biostratigraphic, and carbon isotopic data from shallow marine carbonate sediments exposed in present southern Tibet to evaluate the impact of the PETM on a shallow-water carbonate platform. Detailed biostratigraphy and carbon isotope data indicate that the PETM occurs 3 m below the boundary between nodular and thin-bedded limestones, is maintained up to the thin-bedded limestone and calcareous marl interval, and is followed by recovery at the base of thick-bedded limestone interval. Microfacies analysis testifies to a regression from open to restricted shallow-marine environments at the transition from PETM onset to PETM core, and shallowing continued through the PETM core. Restricted lagoonal deposition was renewed during PETM recovery. These environmental changes were associated with two major turnovers of shallow-water biota. We infer that the first sudden biotic change at the PETM onset may relate to intensified continental weathering, whereas the second biotic change at PETM recovery may have been caused by sea-level fall.

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Special Session 12.7. IGCP739: The Mesozoic–Paleogene hyperthermal events

Oral presentation

Preservation of the mid-Cretaceous hyperthermal event signals in deep and shallow marine paleosetting of Tethys

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One of the intervals of high sea-level, associated with a very warm and humid climate, was the mid-Cretaceous, i.e., from the Albian up to the Turonian. Within this interval most of the Cretaceous Oceanic Anoxic Events (OAEs) were globally recognized, probably linked to intensified volcanism and decomposition of the methane hydrates and the methane of thermogenic origin. Associated with the carbon cycle fluctuations described during all OAEs, both positive and negative $\delta^{13}C$ excursions have been found in the sediment records. These fluctuations most probably correspond to profound oceanic changes, i.e., increase in paleoproductivity, ocean circulation reduction, and periods of paleoclimatic changes as shown by the sea-surface paleotemperature records. We investigated the OAE of the Albian–Cenomanian interval in several Tethyan successions. In some sections, mainly those located in a shallow marine paleoenvironment, such as the Southern Carpathians and the southern Tibetan areas, the Albian–Cenomanian Boundary Interval Event shows a $\delta^{13}C$ significant shift, along with associated biotic fluctuations (mainly of pelagic organisms, such as the calcareous nannoplankton), but the lithological overprint, including the black shale occurrence, was not observed. In the deep marine sediments of the Eastern Carpathians the turbidites and the hemipelagites (sedimented around the CCD) preserved all the signals of mid Cretaceous hyperthermal events, including thin-dm black shales, $\delta^{13}C$ positive excursion and fluctuation of marine planktonic organisms. In all studied successions, the initial phase of the Albian–Cenomanian Boundary Event is accompanied by the increased abundance of the nannofossils supposed to be indicators of surface water high-fertility, but in the interval of $\delta^{13}C$ highest values, they temporary disappeared from the record. This modification mirrors the critical stage of the stressed environmental conditions, possibly linked to the pH and nutrient supply fluctuations, along with the increased of surface water temperature. In conclusion, the biotic and geochemical changes linked to the hyperthermal events of the Albian–Cenomanian Boundary Interval could be recognized in any paleosetting, while the lithological overprint could missed, especially in the shallow marine successions.

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Oral presentation

Pyrite-sulfur isotopes as an indicator of increased sedimentation rate during the Early Toarcian Anoxic Event

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A long history of work incorporating both experimental and field approaches has shown that there are a number of factors such as sulfate concentration, bacterial community, rate of reduction, substrate and sedimentation rate which can affect the sulfur isotope composition of sedimentary pyrite. Recent work has shown that in many cases sedimentation rate is the dominant control (e.g. Pasquier et al., 2021). We present published pyrite-sulfur isotope records from across the early Toarcian anoxic event from proximal shelf and deep ocean sites (Japan, Chen et al., 2022), and new records from an eperic seaway (Mochras borehole UK). In all sections the records show a marked, but variable, increase in pyrite-$\delta^{34}S$ across the event. The effects of changing redox are not consistent with the direction of isotopic change and Fe speciation and trace element records show little consistent correlation with pyrite-$\delta^{34}S$ (Chen et al., 2023). Whilst sulfate depletion has been suggested for this time period, the isotopic difference between pyrite and carbonate associated sulfate-$\delta^{34}S$ is too large for this to be a credible explanation. In the deep ocean setting, the positive sulfur isotope excursion correlates well with enhanced organic carbon and therefore control by increased rate of sulfate reduction. In the two shallow settings, the sulfur isotopic changes occur independently from organic carbon concentrations and likely records increased sedimentation rates driven by enhanced run-off during the volcanically driven early Toarcian oceanic anoxic event and associated hyperthermal.

References

Chen, W. et al. (2022): Major sulfur cycle perturbations in the Panthalassic Ocean across the Pliensbachian–Toarcian boundary and the Toarcian Oceanic Anoxic Event. Global and Planetary Change, 215, 103884.

Chen, W. et al. (2023): Shallow- and deep-ocean Fe cycling and redox evolution across the Pliensbachian–Toarcian boundary and Toarcian Oceanic Anoxic Event in Panthalassa. EPSL, 602, 117959.

Pasquier, V. et al. (2021): Strong local, not global, controls on marine pyrite sulfur isotopes: Science Advances, 7/9, eabb7403.

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Oral presentation

Mercury and zinc cycles during Oceanic Anoxic Event 2

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The Oceanic Anoxic Event 2 (OAE 2, ca. 94 Ma) represents one of the most profound global carbon cycle perturbations of the Phanerozoic. Elemental and isotopic geochemistry studies indicate that hydrothermal sourced metals are enriched in marine sediments of OAE 2. We have examined the mercury and zinc cycles during OAE 2 from rocks deposited in the western Tethys (Austria) and eastern Tethys (Tibet, China). Our results show notable Hg concentration peaks and positive Δ^{199}Hg excursions during OAE 2 in both areas, with no correlation between Hg content and organic matter (OM), Mn-Fe-oxyhydroxides, and/or clay minerals. The excursions in Hg concentration and isotope values are coincident with osmium isotope (Osi) anomalies in southern Tibet. These observations allow us to infer an enhanced volcanic input of Hg into the ocean–atmosphere system. The δ^{66}Zn in the Austrian section abruptly decreases by ~0.5‰ prior to the onset of OAE 2 and remains at low values till the end of the Plenus Cold Event (PCE) interval, which is recorded in the lower part of OAE 2. We interpret the δ^{66}Zn negative shift to reflect an influx of isotopically light Zn sourced from LIP activity as well. However, in southern Tibet the δ^{66}Zn values continuously decrease from the base of OAE 2 to the PCE interval. This is interpreted to reflect increased terrigenous input owing to enhanced weathering intensity. Both of our δ^{66}Zn plots differ from records in Morocco and England, where two rapid negative shifts in δ^{66}Zn were recorded in the lower part of OAE 2 separated by a broad positive excursion. The positive excursion of δ^{66}Zn is due to elevated burial of organic matter resulting in removal of isotopically light Zn from the water column. The different patterns of δ^{66}Zn likely indicate that marine Zn cycling is strongly influenced by regional factors.

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Oral presentation

The first paleoclimatic records of the rudist genus (bivalvia) Dictyoptychus from the Upper Campanian on the Arabian Carbonate Platform, SE Türkiye

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Dictyoptychus specimens from the rudist limestone lenses in the Terbüzek Formation composed of reddish clastics suggesting a late Campanian age of the Arabian Platform, SE Türkiye are studied for stable isotope geochemistry for the first time in Türkiye.

Two articulated *Dictyoptychus* specimens, *Dictyoptychus morgani* (Douvillé 1904) and *Dictyoptychus* sp. are described and the longitudinal sections are obtained by saw cutting. *Dictyoptychus* is adopted in warm and very shallow water conditions around 2–5 meters at depth. Shells are very thick indicating that they can tolerate currents, sediment influx and water temperature fluctuations. They are found as in life position within fan delta and platform transition. Therefore sediment infillings are partly or mostly recorded within the rudist shell.

Sampling is done along the well preserved growth lines by micromilling at 1.5 mm interval and analysed in Thermo Finnigan Delta plus XP Mass Spectrometer in central laboratory of Middle East Technical University.

Stable isotope analysis performed on two rudist specimens about 20 cm in lenght yielded very interesting ^{13}C and ^{18}O values ranging -0.45‰ and 2.33‰ and -6.93‰ and -1.77‰ respectively for the specimen one and -0.32‰ and 2.03‰ and -5.42‰ and -2.13‰ for the specimen two. The average ^{13}C and ^{18}O values for specimen 1 are 1.36‰ and -4.79‰ respectively, and average ^{13}C and ^{18}O values for specimens 2 are around 1.26‰ and -4.47‰ respectively. Samples from calcite sparr and internal infilling is below or around the average values of two samples. This may indicate that results were influenced by diagenesis but strongly masked.

Paleotemperature differences for the specimen 1 range between 43.99° and 18.4° and for the specimen 2 it range between 35.78° and 19.96°. Paleotemperature data are obtained with using formulae of Holser et al (1996) and Shackleton and Kennett (1975). The average paleotemperature for specimen 1 is about 32.08 ° and for specimen 2 is about 30.92. These values are consistent with the global Late Cretaceous paleoclimate values.

Paleotemperature differences between growth cycles composed of alternation of bundles of darker and lighter growth lines range from 6° to 12°.

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Special Session 12.7. IGCP739: The Mesozoic–Paleogene hyperthermal events

Oral presentation

Sedimentary response and palaeoenvironmental perturbations related to the continental Permian–Triassic hyperthermal crisis in North China

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The link between the Permian–Triassic mass extinction (PTME) and palaeoenvironmental perturbations on land is still debatable. Here we evaluate the possible palaeoenvironmental perturbations and highlight the significance of sedimentary response in North China to the PTME on land. The Permian–Triassic boundary (PTB) is marked by the synchronous carbon isotope ($\delta^{13}C$) excursion, the peak of mercury (Hg/TOC) and geochemical signals of weathering intensity, which support the deteriorated palaeoenvironment and impact of volcanism. We document a basin-wide (>500 km across) meandering river system of point bars and floodplains to variable braided river–aeolian system dominated by thick, multistoried, sheets of sandstones across the PTB. The abrupt coarse-grained lithofacies transition across this key interval persists in the Induan and is concomitant with sharp carbon dioxide injection into the atmosphere, which may reveal the rapid increases in sediment flux and intensified hydrological cycle in response to the sharp warming across the PTB. Collectively, the continental PTB in North China recorded the biotic crisis and deteriorated palaeoenvironment on land and the synchronous massive volcanism might be a significant trigger.

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Poster presentation

A multiproxy record of the Paleocene–Eocene Thermal Maximum at the Contessa road section, Italy

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The Paleocene–Eocene Thermal Maximum (PETM, ~55 Ma) records one of the most severe and intensively studied hyperthermal events which is often proposed as a yardstick to current global warming. The PETM was associated with the massive injection of carbon to the ocean–atmosphere system and major environmental changes. The temporal coincidence between the PETM and the emplacement of the North Atlantic Igneous Province suggest that magmatism could have contributed to the initiation of the global-change event. Although several studies have already advanced our understanding of the causes and consequences of the PETM, there are still some aspects of the Earth's climate regulation that remain understudied. In particular, the long-term palaeoenvironmental evolution, the feedback mechanisms enabling the climate to stabilise and regulate across the PETM, and the associated timescales are still highly debated. In this presentation, the Contessa Road succession has been selected to have a deep marine record of the PETM. The study is based on a multiproxy approach, which provides keys to assess the palaeoenvironmental changes associated with the PETM and constrain the feedback mechanisms governing the carbon cycle–climate dynamics. The studied Contessa Road succession encompasses the Paleocene–Eocene transition and is mainly composed of reddish marly carbonates, sometimes bioturbated, with discrete clayey interbeds, which were deposited in the pelagic Umbria–Marche Basin (Italy). The PETM interval is marked by two clay-rich intervals supposed to reflect dissolution levels. This section is correlated to coeval sites by means of organic and inorganic carbon isotope stratigraphy. Whole-rock and clay mineralogy provide constraints on the changes in the palaeoclimatic conditions and weathering rates, total phosphorus content allow us to determine nutrient levels, and mercury and tellurium contents to assess the role of the NAIP volcanic activity in governing the pattern of the PETM. Combined with other findings from world-wide-distributed coeval sites, the new mineralogical and geochemical dataset offers a holistic understanding of the carbon cycle–climate dynamics and of the feedback mechanisms enabling the climate to stabilise after extreme environmental perturbations.

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Poster presentation

Response of the Late Paleocene–Eocene sediments to relative sea-level changes in High Zagros, Lorestan

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The Late Paleocene–Eocene sediments in the Lorestan region outcrop along the Zagros Suture Zone were considered for evaluating climate–tectonic interaction upon these sediments. The Darb-e Astaneh stratigraphic section is approximately 450 m thick and contains red shale and sandy limestone at the base, and green marly limestone, marl, and limestone toward the top. This succession unconformably covers the Kashkan Formation and is overlain by the Oligo-Miocene Asmari Formation. Pabdeh Formation with pelagic to hemipelagic dominant facies has been deposited during a relative sea level rising after the red fluvial conglomerate Kashkan Formation. A lens shaped layer rich in microbialites has been recorded at the top of the Kashkan Formation. Based on the field and petrographic studies, the microfacies for the Late Paleocene–Eocene succession include sandy peloidal bioclastic grainstone, peloidal bioclastic packstone, mixed benthic and planktonic foraminifera wackestone/packstone, planktonic foraminifera wackestone, and argillaceous planktonic foraminifera wackestone that were developed in the shallow carbonate platform, slope, deep shelf, and deep basin. Pabdeh Formation consists of two shallowing upward cycles: the peloidal bioclastic grainstone/packstone facies related to the shallow carbonate platform and turbidity current facies were formed during the sea-level highstand (HST), while shale, hemipelagic, and marls-dominated successions were developed during relative sea-level rise (TST). Comparison of the facies changes in the Pabdeh Formation with the local sea level change curve indicates a close agreement during Early–Middle Eocene and disagreement from Middle Eocene–Oligocene in the Zagros Suture Zone. Therefore, sea level fluctuation was a more powerful factor in the sedimentary facies changes in the lower parts. However, tectonic processes were a more impressive proxy in the upper part of the Pabdeh Formation. This kind of study is not only useful for understanding paleoclimate changes but also helpful for the detection of the anoxic events in the Zagros domain.

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Poster presentation

Time response of the climate system at the onset of the early Aptian OAE 1a

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The early Aptian Oceanic Anoxic Event (OAE 1a) records a major perturbation in the global carbon cycle that led to significant palaeoenvironmental changes, associated with a light-carbon input into the climate system from volcanogenic (Ontong–Java Plateau) and/or methanogenic sources. The global signature of this event is a negative followed by a positive carbon stable isotope excursion (CIE, isotope segments C3–C4), which correlates with the widespread massive accumulation of organic matter in all major ocean basins. The response of the atmosphere–marine system to such climatic perturbations is greatly dependant on its self-regulation capability. Here, we examine the temporal relationship between the massive input of light-carbon and the associated palaeoenvironmental changes at the very onset of the CIE (base of segment C3). For that, we combine new data from high-resolution C-isotope stratigraphy, biormarker, major and trace element concentrations and TOC content, from an expanded pelagic succession in the Subbetic Basin (Carbonero section, SE Spain).

This geochemical analysis has revealed a time-lag between the massive light-carbon input in the climate–atmosphere system, as recorded in the negative C-isotope excursion, and the first record of the palaeoenvironmental changes. Increases in primary productivity and continental inputs are evidenced by the increasing trends of key trace elements concentrations (Rb, Mg, K and Zr for continental sources, P and Ba for productivity), TOC content (up to 7 wt%) and biomarker proxies (mainly C27–C29 steranes distributions and HMW/LMW ratio), which are recorded 1.5 m above the level documenting the entrance of massive light-carbon input (base of the negative carbon-isotope excursion). Based on published estimations of sedimentation rates in the Carbonero section (around 6 cm/kyr), our results indicate that the palaeoenvironmental changes of this event are first documented ca. 25 kyr after the carbon cycle perturbation was recorded. At this time, the development of suboxic/anoxic conditions also occurred, indicated by increasing trends in redox elemental proxies (Ni/Co, V/Cr, V/Al, U/Al, Cr/Al, V/Sc), decrease of Pr/Ph ratio, and the presence of 2Methylhopanes (associated to environmental stressing conditions).

Theme 12. Stratigraphic markers and archives

General Session

Oral presentation

Sedimentary signature of seismicity induced by asteroid impacts: the Chicxulub mega-earthquake (Cretaceous–Paleogene boundary)

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Mega-earthquakes (Moment magnitude, $M_w \geq 8$) are catastrophic events relatively common in the geological record. Megathrust subduction faults have caused the largest earthquakes ever recorded in history, but the magnitude is related to the length of the faults along which it occurs. No fault long enough to generate an earthquake with a magnitude greater than 10 is known to exist. The 1960 Valdivia earthquake was the most powerful mega-earthquake ever recorded, with a $M_w=9.5$, affecting a fault of ~1,000 miles long along the Peru–Chile trench. Contrary to faults, asteroid impacts can potentially release sufficient energy to generate mega-earthquakes with a magnitude greater than 10. The Chicxulub asteroid impact (66 Ma) in what is now the Yucatan Peninsula, Mexico, coincides with the age of the Cretaceous–Paleogene boundary (KPB). The environmental consequences of this collision are the most likely cause for the last one of the "Big Five" extinction events in the Phanerozoic. Geophysical models suggest that the impact released energy equivalent to 10^{23} joules, enough to generate colossal earthquakes and aftershocks for weeks to months. To test this, we have examined in detail the sedimentary record of several KPB sections from Colombia, Mexico, and the United States to reconstruct the aftermath of this planetary event. Here we show that in all the sections studied, it is possible to identify evidence of faulting and fracturing, in-situ liquefaction, and intense soft-sediment deformation before, during, and after the fall of the ejecta and the deposition of sediments washed away by the tsunami waves. Such observations can be attributed to the Chicxulub mega-earthquake and its aftershocks, proving intense seismic activity for months to years after the bolide impact in areas located thousands of kilometers away from the crater. Our new sedimentological evidence can help better understand the complex stratigraphic record of the KPB and characterize one of the biggest earthquakes experienced by our planet in the Phanerozoic.

Theme 12. Stratigraphic markers and archives

General Session

Oral presentation

Magnetostratigraphy of potential Tithonian–Berriasian boundary sequence at Golubac (Serbia): correlation to biostratigraphy record

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Worldwide definition of the Jurassic–Cretaceous (J–K) boundary is still not established. High-resolution magnetostratigraphy is one of the three most important correlation tools for the J–K boundary recognition. Furthermore, it can be applied as a correlation media between various depositional environments and biostratigraphic markers. The Golubac, 110-m-thick sequence, is located in the National Park Đerdap, NE Serbia, in the northernmost part of the inner Carpathian–Balkan belt. Due to specific and very diverse geological structure, it is a particularly interesting part of the Carpathian–Balkan areas. The sequence was studied using multiple methods, such as paleomagnetism, rock-magnetism, biostratigraphy, geochemistry and sedimentology. Magnetic methods were used to determine the components and carriers of remanent magnetization. Identifying the primary magnetization is especially important in Golubac, where 3 generations of magnetizations are identified. The results indicate the presence of both normal and reverse polarity primary magnetization components. The declination suggests a clockwise rotation. Furthermore, part of samples shows also secondary component with normal polarity and counter clockwise rotation. Primary dual polarity component was used to compile the magnetostratigraphy chart which was correlated with the biostratigraphy and M-sequence of marine magnetic anomalies of the Global Polarity Time Scale (Ogg, 2020). Based on Calpionellid zonation, the J–K (Tithonian–Berriasian) boundary could be located near the base of the sequence, while ammonites belong to the lower Berriasian.

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Reference

Ogg, J. G. in Geologic Time Scale 2020 (eds. Gradstein, F. M., Ogg, J. G., Schmitz, M. D. & Ogg, G. M.) 159–192 (Elsevier, 2020).

Theme 12. Stratigraphic markers and archives

General Session

Oral presentation

Plankton stratigraphy provides a mid-Paleogene age constraint for the Dalmatian Flysch in External Dinarides foreland basin

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Flysch marks the synorogenic deposition in external foreland fold-and-thrust belts (FATB) around the globe. Thus, a precise estimation of its stratigraphic range is crucial for reconstructing the orogenic histories in these belts. Dinarides FATB is a young orogen settled between the Alps and the Hellenides in SE Europe originating from the NE-wards subduction of the Adriatic plate under the Eurasia. The youngest onshore flysch deposits termed the Dalmatian Flysch mark the position of the External Dinarides foreland basin (EDFB) stretching both over its interior High Karst as well as its exterior Dalmatian tectonic unit. There is an ongoing discussion on its stratigraphic context, contrasting a Paleogene with a Neogene age. Such a difference in age estimation provides severe uncertainties for the reconstruction of tectonic and paleogeographic constrains. In particular, the Neogene age of the Dalmatian Flysch would imply the coexistence of contractional and extensional tectonics in the Miocene of External Dinarides; the latter marked by establishment of numerous intramountain basins encompassing a long lasting lacustrine environment of the so-called Dinarides Lake System. To test the hypothesis on such coexistence, 76 sediment bulk-samples have been collected from 31 sites of the Dalmatian Flysch referred to by current literature as Miocene. They are distributed along a 400-km-long axial transect of the EDFB in Croatia, Bosnia–Herzegovina, and Montenegro between cities of Pag in the NW and Ulcinj in the SE. In contrast to previous studies, we use the calcareous plankton stratigraphy integrating nannoplankton and foraminifera records. Our preliminary results detected neither the presence of Miocene, nor of Oligocene assemblages in the samples. This result is supported by the occurrence of well-preserved planktonic foraminifera including the Middle to Late Eocene stratigraphic markers *Globigerinatheka barri*, *Hantkenina compressa*, and *Morozovelloides crassatus*. The corresponding stratigraphic interval is corroborated by the calcareous nannoplankton assemblages comprising index species such as *Sphenolithus furcatolithoides*, *Cribrocentrum reticulatum*, *C. erbae*, and *Furcatolithus obtusus*. Accordingly, the present data prove a marine offshore deposition in the EDFB during the Oligocene and the Miocene improbable.

Theme 12. Stratigraphic markers and archives

General Session

Oral presentation

Mud matters: sedimentological evidence demonstrates how silicate mineral weathering evolved in synchrony with the first land plants

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Land plants play an important role in the carbon cycle, in part through the weathering of silicate minerals. Yet ideas about how the first evolution of plants impacted the carbon cycle are often contradictory. There is empirical evidence that the middle Paleozoic Era witnessed a shift in the source-to-sink distribution of mud, recorded as a 20-fold increase in the total abundance of alluvial mudrock. Plant-induced baffling, stabilization, and flocculation retained more mud on land, and potentially acted in concert with increased mud production through plant-mediated chemical weathering. The notion of heightened mud production by early plants has been challenged because it is perceived to require an imbalance in the long-term carbon cycle. While accepting that any chemical weathering fluxes must have balanced planetary emissions of CO_2, we nonetheless find from a range of evidence that there was indeed a plant-induced increase in mud production through chemical weathering: 1) The Paleozoic mudrock increase was pronounced even within areas away from any biomechanical influence of plants, with submerged in-channel bars showing a steady increase in total mudrock content and suggesting heightened fine sediment concentrations from the hinterland after plants evolved; 2) SEM-EDS mineral mapping of several pre-vegetation continental mudrocks reveal a striking paucity of chemically weathered clays, with mineral assemblages instead dominated by physically weathered illite and chlorite; and 3) Clay mineral assemblages from mudrocks deposited in vegetated Paleozoic environments contain a greater abundance of chemically weathered clays, and potentially archive a stratigraphic shift in clay mineral motifs. Earth's mudrock record supports the hypothesis that the Paleozoic expansion of land plants not only acted to stop mud from leaving the continents, but also reorganized the carbon cycle by enabling new pathways in hinterland chemical weathering and mud production.

Theme 12. Stratigraphic markers and archives

General Session

Oral presentation

Searching for a candidate section for the new basal Emsian GSSP in the Prague Synform

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The current basal Emsian GSSP was defined in the Zinzil'ban Gorge (Kitab State Geological Reserve, Uzbekistan) based on the FAD of conodont *Polygnathus kitabicus* Subsequent detailed correlations revealed that this GSSP lies far below the base of the classical Emsian in the German sense and correlates with a level in the lower half of the Praha Formation (Prague Synform, Czech Republic), whereas this formation roughly corresponds to the "original Pragian". In 2019, the Subcommission on Devonian Stratigraphy decided to look for a new appropriate section for the redefined basal Emsian GSSP. The most promising candidates are situated in the Spanish Central Pyrenees and in the Prague Synform. The main task of the ongoing project is to prepare a proposal for the GSSP of the basal Emsian boundary in the Prague Synform, whose Lower Devonian successions have been intensively studied for more than a century. The *gracilis* Event represents an alternative marker approximately corresponding to the traditional boundary between the Pragian and Emsian stages. The Bohemian Graptolite Event beds represent a significant correlation horizon in the upper parts of the Praha Formation with great potential for future redefinition of the basal Emsian global stratotype (GSSP). The conodont taxa *Polygnathus excavatus excavatus* and *Latericriodus bilatericrescens gracilis*, which might be critical for the potential definition of a new basal Emsian GSSP, similarly enter close to this level. In this contribution, we will present the biostratigraphic (conodont biostratigraphy), sedimentological (e.g., microfacies), ichnological, geochemical (INAA, EDXRF, $\delta^{13}C$ and $\delta^{18}O$) and petrophysical (GRS measurements, magnetic susceptibility) data obtained from the three most promising sections.

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Theme 12. Stratigraphic markers and archives

General Session

Poster presentation

Investigating the link between Devonian anoxic events and astronomical forcing: a two-pronged approach of cyclostratigraphy and numerical modeling

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The Devonian geological record bears evidence of 29 regional-to-global anoxic events, some of which are linked to major extinction episodes. Even though a consensus on the mechanisms behind these events has not yet been reached, clues have been uncovered that suggest a link between the pacing of ocean anoxia and astronomical forcing (2.4 Myr eccentricity nodes) for the Kellwasser Event. Devonian anoxic events are commonly characterized by a positive $\delta^{13}C$ excursion (CIE) and often expressed as organic-rich black shales interbedded in carbonate-dominated sediment. However, absence of a positive CIE and expression of anoxic events as an unconformity, facies change or hiatus have been reported as well – i.e. the expression of anoxic events is variable and depends on the paleoenvironment and paleogeography. In addition, most reports on Devonian anoxic events suffer from significant sampling bias, focusing mainly on the pantropical belt or being restricted to only a few localities. In the 'WarmAnoxia' project we will attempt to consolidate existing and new observations from geological records with scenarios provided by numerical modeling to assess existing hypotheses and underlying mechanisms. Preliminary simulations with the model cGENIE show that the extent of the oxygen minimum zone is inversely proportional to the atmospheric CO_2 concentration and, that part of the upper ocean is close to hypoxic/anoxic conditions at an atmospheric oxygen level of 70% of the current value. We also provide preliminary simulations of soil dynamics, nutrient fluxes, atmospheric oxygen levels and oceanic chemistry response by combining a complex atmosphere model with a module for soil dynamics and an ocean box model. A hierarchy of models will continue to be used to test a range of physical and biogeochemical hypotheses linking astronomical forcing to anoxia. On the other hand, application of cyclostratigraphy and carbon isotope stratigraphy will be used to constrain the temporal (phase) relationship between astronomical forcing and anoxic events recorded in the sedimentary record. Via the proposed two-pronged approach, it will be investigated whether complex multicausal factors and the 2.4 Myr eccentricity nodes can be associated with other Devonian anoxic events, either as a window of opportunity or rather the decisive trigger.

Theme 12. Stratigraphic markers and archives

General Session

Poster presentation

New insight into the K/Pg boundary interval at Nasiłów (biostratigraphy and paleomagnetism), Poland, Central Europe

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The Nasiłów section represents the uppermost part of the Middle Vistula River succession, a classic extra-Carpathian Cretaceous section in Poland and accesses to the Cretaceous–Paleogene boundary interval. Our recent studies shed new light on the completeness of biostratigraphical and sedimentary records across the K/Pg at the site. It encompasses the upper Maastrichtian regional foraminiferal assemblage zones XII and XIII and lower Danian P_0–P_α standard planktic foraminiferal zones. The K/Pg boundary is placed at the top of a "phosphatic layer" (Remin et al., 2021). The grey marly chalk unit, never subjected to examination of biostratigraphically important taxa, displays blooms of guembelitrids, indicative of the uppermost Maastrichtian (foraminiferal assemblage zone XIII), as well as of planktic and benthic foraminifera of reduced test sizes. Such foraminiferal dwarfism is commonly observed near the end of the Cretaceous and interpreted as a response to Deccan volcanism (possibly 2nd phase) which caused climate changes and ocean acidification. The "Greensand", a distinct glauconite–quartz sand unit, contains exclusively terminal Maastrichtian planktic foraminifera and dinoflagellate cyst assemblages. Single specimens of Danian age are interpreted to be either the result of contamination or as having been piped down by burrowers into the Greensand. The lowermost portion of the Siwak (over the Greensand) unit demonstrates an early Danian age, as based on the co-occurrence of the common planktic foraminifera, especially *Globoconusa daubjergensis* among others. The last occurrence of *Palynodinium grallator* and the first occurrences of *Carpatella cornuta* and *Senoniasphaera inornata*, recorded directly above the "phosphatic layer", support the same age assignment. New palaeomagnetic data cannot prove the remagnetisation at the boundary interval previously recognized in the studied site. All this is in line with new biostratigraphical data (Remin et al., 2021).

Reference

Remin, Z., Cyglicki, M., Barski, M., Dubicka, Z. and Roszkowska-Remin, J. 2021. The K–Pg boundary section at Nasiłów, Poland: stratigraphic reassessment based on foraminifers, dinoflagellate cysts and palaeomagnetism. Geological Quarterly, 65 (45), doi: http://dx.doi.org/10.7306/gq.1614.

Theme 12. Stratigraphic markers and archives

General Session

Poster presentation

Redeposited mud in hybrid event beds hinder the applicability of the authigenic $^{10}Be/^{9}Be$ dating: eastern Danube Basin, Slovakia

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Authigenic $^{10}Be/^{9}Be$ dating is a promising method with the ability to date mudstone up to 14 million years, providing that the initial isotopic ratio could be determined and that the input of isotopes remained stable over the dated period. In a recent case study redeposition of mud violated the condition of stable beryllium isotopic input in a fluvial environment. This study is focused on the transition from Serravalian (Sarmatian) to Tortonian (Pannonian) deposits in the borehole Kolárovo-4 in the eastern Danube Basin. Their boundary is associated with an environmental change from the Central Paratethys Sea to the isolated water masses of Lake Pannon. Both units were formed in deep waters by sediment gravity flows, divided by an unconformity and a likely period of denudation. The authigenic $^{10}Be/^{9}Be$ dating using the lacustrine initial ratio (determined in previous studies) yielded false ages of ~13–14 Ma for the Lake Pannon deposits, which are independently dated to ~11.6–10.0 Ma. These basin floor deposits were accumulated as muddy hybrid event beds (HEBs) when the topographic differentiation of the lake bottom likely exposed extensive Middle Miocene successions prone to erosion. Upper Miocene hybrid event beds consist of recycled old mudstones with rich occurrence of Middle Miocene foraminifers, nannoplankton, and the overall character of biomarkers resembling the Sarmatian and Badenian strata instead of the Pannonian lacustrine ones free of HEBs. Hence, this study imply that re-deposition of mud in deep-water environments should be considered in sampling strategies for the authigenic $^{10}Be/^{9}Be$ dating.

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Theme 12. Stratigraphic markers and archives

General Session

Poster presentation

Comments on the microproblematicum *Menselina* Antropov, 1967

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Menselina Antropov, 1967 represents a microproblematicum known from the uppermost Famennian (Devonian) of France, Belgium, Netherlands, Germany, Poland, Afghanistan, Ukraine, Kazakhstan, Russia and China. To date, seven species of the genus *Menselina* have been described: *Menselina clathrata* Antropov, 1967; *Menselina lata* Berchenko, 1981; *Menselina magna* Berchenko, 1981; *Menselina rotunda* Berchenko, 1981; *Menselina triangulata* Berchenko, 1981; *Menselina tchingissica* R. Ivanova, 1990 and *Menselina nana* Mamet, 2011. These cone-shaped microfossils have been classified e.g. as possible red algae, algae incertae sedis or hydroids. Some authors mentioned their similarity to the Cambrian tommotiid *Tannuolina* Fonin & Smirnova, 1967 or the Carboniferous alga *Cylindrofolia glenisteri* Brenckle & Grooves, 1987, the similarity of their overall shape to the cirriped or machaeridian annelid skelets, the similarity of their internal structure to those of echinoderms or their similarity to representatives of Labyrinthoconidae (Algospongia). This contribution is focused on *Menselina* specimens from the uppermost Famennian calciturbidites from the Moravian Karst (Bohemian Massif, Rheno–Hercynian Zone, Czech Republic). The studied material includes specimens observed in thin-sections as well as specimens obtained from the insoluble residue after dissolving limestone samples in 10% acetic acid. We will discuss the morphology and possible suprageneric attribution of this microproblematicum. Attention will also be paid to microfacies, associated fossils and detailed conodont and foraminifer biostratigraphy.

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Theme 12. Stratigraphic markers and archives

General Session

Poster presentation

Environmental rhythms across the onset of the Late Devonian Kellwasser Crisis recorded in the Usseln Limestone (Rhenish Massif, Germany) – a high-resolution study

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The Late Devonian Kellwasser Crisis at the Frasnian–Famennian boundary (ca. 372 Ma) was among the largest mass extinctions of the Phanerozoic, marked by a major perturbation of the global carbon cycle and widespread organic-rich shale deposition. Yet, despite decades of research, the cause of the Kellwasser Crisis remains debated. In large parts of Germany, the first black shale of the Kellwasser interval is underlain by a massive, banded limestone unit termed the 'Usseln Limestone'. Its prevalence and temporal position immediately before the Kellwasser Crisis makes the Usseln Limestone an archive of environmental variations leading up to the extinction event. Here, we pursue a micrometer-scale investigation of the Usseln Limestone across the Rhenish Massif to establish a record of those environmental changes. Using thin-section petrography and µXRF elemental mapping we investigate the evolution of redox and oxygenation states. The Usseln Limestones consist of centimetre-scale clay-rich and carbonate-rich alternations. We interpret these to occur on sub-Milanković, millennial timescales. These underwent early diagenetic carbonate cementation, as the clay-rich intervals exhibit soft-sediment deformation while the carbonate-rich intervals contained fractures and nodule formation. Further features are abundant pyrite content, low-diversity fossil assemblages, variable levels of bioturbation, and in some locations an increase in organic matter content towards the top. The comparison of the Usseln Limestone across three different sites (Winsenberg, Arfeld, and Steinbruch Schmidt) and different depositional settings reveals that deep basinal waters were already experiencing low oxygen conditions before the onset of black shale deposition in the Rhenish Massif region. The anoxia may have been intermittent rather than persistent in some locations and part of an ongoing worsening environmental state leading to the Kellwasser Crisis.

Theme 13. Provenance of sediments – from source to sink

Special Session 13.2. Controlling factors of sediment generation in source to sink studies

Oral presentation

Provenance of terrestrial deposits from whole-rock geochemistry? Example from the Permo-Triassic of Central Europe illustrates that discrimination is possible

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We demonstrate how provenance of terrestrial deposits can be discriminated from whole-rock geochemical data. This is a new approach as earlier studies on geochemical indices have focused on marine deposits. Our case study includes the Permian Rotliegend and the Triassic Buntsandstein groups, and equivalents, in central Europe. Both units had mainly felsic sources. The study is based on >1100 samples, mostly of sandstone. K_2O/Na_2O efficiently differentiates sandstone from different regions (Permian: <1 in NW Germany, >1 in NE and central Germany, and the Netherlands; Triassic: <4 in W Germany, >20 in Bavaria, SW Germany and E France, intermediate values in central Germany). The compositional variation is in line with reported variations in feldspar compositions and indicates local catchments. Thus, the feldspar has been preserved in the arid climate due to the limited weathering. Y/Co, in combination with other indices (e. g., Th/V, Ti/Nb, Th/Sc), was one of the most successful mafic-felsic trace-element indices that we used (Permian: <1 in NE Germany, > 2 in NW Germany, intermediate values in central Germany; Triassic: <3 in S Denmark, Hesse in central Germany, SW Germany and E France, >3 in N Denmark and Thuringia in central Germany). We postulate that the trace-element variation is governed by mineral inclusions mainly in feldspar. V/Zr and Zr/Sc mostly correlate with Y/Co, which indicates different zircon affinity in the source rocks rather than sorting. More felsic compositions and higher Zr/Sc for Triassic than Permian strata are in line with more sedimentary recycling during the Triassic than Permian. We conclude that provenance-related compositional variations can be detected for terrestrial deposits both from oxide and trace-element ratios, even when the source rocks in the different catchment areas mainly are felsic.

Theme 13. Provenance of sediments – from source to sink

Special Session 13.2. Controlling factors of sediment generation in source to sink studies

Oral presentation

Tracing the origin of chlorite in sedimentary basins – a source-to-sink approach

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In many sedimentary basins, the reservoir quality of sandstone is linked to the presence of chlorite grain coatings occurring during the early stages of burial. Chlorite coats can preserve the reservoir quality of sandstone during deep burial by inhibiting extensive quartz overgrowth. The main objective of this study is to establish a source-to-sink model for the formation of chlorite in sedimentary basins using a multiscale approach (X-ray diffraction, transmission electron microscopy, petrography, heavy mineral analysis, and U/Pb dating of zircons). We focus on the Agat Formation (Fm) in the Northern North Sea, which is considered one of the most important chlorite-bearing reservoirs during the Lower Cretaceous. Our results show that the sandstones are mainly sourced from the Western Gneiss Region in Norway from mixed rock types (eclogites/coesite, quartzo-feldspathic gneisses and granitoids). The source of chlorite in the Agat Fm was mainly linked to lateritic soil profiles developing on Norway's mainland under warm, humid climates providing a large amount of Fe during the Aptian–Albian period. The Fe supplied by the river systems is trapped near major river mouths due to flocculation, allowing a strong accumulation of Fe-clays in shallow marine environments. These shallow marine sands were reworked during marine regression and transported by turbidity currents, forming slope fans. Chlorite formation during burial occurred in two steps: first a berthierine precursor was formed during the early stages of burial favored by the dissolution of Al and Fe-rich detrital grains and fine fraction materials at low temperatures under reducing conditions. This was followed by the transformation of berthierine into chlorite at higher temperatures (>50 °C) through a solid-state transformation. The findings of this study provide important insights into predicting chlorite coat emplacement in sedimentary basins, helping to identify new potential hydrocarbon prospects in deeply buried sandstones.

Theme 13. Provenance of sediments – from source to sink

Special Session 13.2. Controlling factors of sediment generation in source to sink studies

Oral presentation

The auto- and allogenic forces in grain-size spatial distribution within large-scale ancient erg

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Dune fields grain-size spatial distribution is ruled by joint allogenic forces, as sand provenance and wind-direction pattern, and autogenic forces, as aeolian abrasion and sorting due to wind transport. Studies from modern deserts find conflicting results in terms of grain-size spatial distribution. Although experimental studies measure the magnitude of aeolian abrasion and predict a grain-size fining and sorting during aeolian transport, modern examples not always register coarse-to-fine patterns along wind-direction transects. For instance, Ténére, Australian and Sinai deserts show similar grain-size distribution along wind direction, while Namib and Hexi deserts demonstrate fining downwind. Such contrast in desert data suggests that different controls are competing for ruling the grain-size spatial distribution. To test the roles of allogenic forces (wind-direction and provenance) and autogenic (aeolian abrasion) this study utilizes a multiproxy dataset from the Cretaceous Botucatu Desert (>1,000,000 km^2) in South America and Africa. This study compares the spatial distribution of sand grain-size sampled in cross-stratified aeolian sandstones with U–Pb detrital zircon, palaeowind direction, and downwind mean grain-size downwind in 3 transects, to check the effects of provenance, wind-direction and aeolian abrasion, respectively. The south transect finds a coarsening downwind, mirroring the provenance changes laterally, which suggests that provenance is the most prevalent control for desert sand grain-size. Aeolian abrasion dominates in NE transect, finding a decrease 0.4 µm by km, illustrating that aeolian abrasion occurs but its effect can be overruled by a mixture of sources due to provenance changes.

Theme 13. Provenance of sediments – from source to sink

Special Session 13.2. Controlling factors of sediment generation in source to sink studies

Oral presentation

Signatures of provenance and paleogeographic changes revealed through quantitative heavy-mineral analysis, single-grain garnet chemistry and zircon U-Pb geochronology: Mesozoic Kutch Basin, India

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The peri-cratonic Kutch Basin preserves a largely undisturbed sedimentary record of the Indian subcontinent during its break-up from Gondwana and subsequent northward drift. The Middle Jurassic to Lower Cretaceous sequences were deposited in several sub-basins within the Kutch Basin and are classified into Kutch Mainland Group (KMG), Pachchham Island Group (PIG) and Eastern Kutch Group (EKG). This study reveals differences in sediment source amongst these sub-basins with the help of heavy-mineral assemblages, single-grain garnet chemistry and zircon U-Pb ages. The heavy-mineral contents for apatite, garnet and staurolite suggest different course of evolution for PIG in contrast with KMG-EKG. Proportion of igneous garnets reduces in younger sedimentary rocks of PIG while this trend is opposite in KMG-EKG. Sedimentary rocks younger than Callovian are not preserved in PIG whereas rocks of this age in KMG-EKG exhibit significant increase in staurolite and kyanite content. Both in KMG and EKG, Callovian and younger rocks exhibit presence of garnets from blueschist–greenschist metamorphic facies as well as Mn-rich igneous garnets. Zircon U-Pb data for the three groups indicate source rock ages ranging from 400 to 3500 Ma. Sources equivalent to 500–650 Ma and 400–500 Ma remain dominant contributors to all three groups. In KMG and EKG, contribution from source rocks belonging to 400–500 Ma increases from the Callovian onward. Therefore, changing individual heavy-mineral content, garnet chemistry and Zircon U-Pb ages in KMG and EKG indicate input from additional sources in younger sediments starting in Callovian. This, in combination with a lack of sediments in PIG correlates to the rise of a sub-surface basement ridge in the basin – the Median High. This may have blocked sediment supply for PIG and diverted their transport for KMG-EKG.

Theme 13. Provenance of sediments – from source to sink

Special Session 13.2. Controlling factors of sediment generation in source to sink studies

Oral presentation

Inherited grain size distributions: effect on heavy mineral assemblages in modern and ancient sediments

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Heavy mineral (HM) suites relay key information that aid in connecting source and sink during provenance studies. Normally, the distribution of HM reflects the diverse mineralogy of the parent rocks where the sediment originated. Hydraulic processes and sorting due to grain size, density, and shape exert strong control on these distributions. However, chemical weathering at the source, mechanical abrasion whilst in transport, and diagenetic processes during burial can all modify HM proportions. Another factor, explored here, is grain size inheritance of the source rock resulting in an absence of finer or coarser grains of a particular HM species. Using examples from both modern and ancient deposits, we are trying to unravel the consequences grain size inheritance may pose on HM distributions. For the modern sediment, a placer deposit and related foreshore sand were sampled from a beach in NW Denmark. Turbidite successions were chosen for the ancient example and three sites spread across Austria selected. Beach placers are typically sediments that have experienced significant transport energy, thus predominantly controlled by hydrodynamic processes. In contrast, turbidites can have varying hydrodynamic processes acting on them, and – if lithified – are notably difficult to process and interpret due to diagenetic controls. All samples were processed for HM separation, mounted in epoxy, and measured using Raman spectroscopy. HM distributions varied greatly both between samples from the same site and between grain size intervals. Two main techniques are used to try separating the effects of grain size inheritance from hydrodynamics: indices from Morton & Hallsworth (1994) which compare relative abundances of two hydrodynamically similar HM, and the MinSORTING program from Resentini et al. (2013) which models 'ideal' hydrodynamically sorted HM distributions. In the placer deposit, HM distributions reflect the extensive hydraulic processes they have undergone as expected. However, evidence of grain size inheritance is still visible with a greater proportion of finer zircons and coarser garnets when compared with the model distribution. A stronger effect is seen within the turbidites, with a lack of both coarse zircons and tourmaline, and less indication of hydrodynamic controls on the HM distribution.

References

Morton, A. & Hallsworth, C. (1994): Sed. Geol., 90(3-4), pp. 241–256.
Resentini, A. et al. (2013): Computers & Geosciences, 59, pp. 90–97.

Theme 13. Provenance of sediments – from source to sink

Special Session 13.2. Controlling factors of sediment generation in source to sink studies

Oral presentation

Glacial cycle induced change in sediment transport through blind canyons: a case study from the eastern Mediterranean Sea

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Submarine canyons play an important role in sediment transport to the deep sea by serving as conduits for turbidity currents. The nature of sediment transport through the canyons is affected by orbital-timescale sea level changes, most profoundly in blind (continental-slope confined) canyons that are incised during glacial low stands. This research focuses on the Nahariya blind Canyon, located along the continental slopes of the eastern Mediterranean, offshore northern Israel. Its goal is to reconstruct the canyon geological history and current activity. Two piston-cores were sampled along this canyon thalweg at water depths of 650 m (NAC650) and 915 m (NAC915); the cores were ~2.5 m and ~4.5 m long, respectively, and their age models were established based on ^{210}Pb and radiocarbon dating. Sediments were characterized by their CT tomography based stratigraphy, chemistry, particle size distribution and foraminiferal assemblages. Cores consist of mostly homogenous sediment dated to the last glacial (>41 and >23 ka in NAC650 and NAC915, respectively), unconformably capped by ~40 cm thick fine laminated mud reflecting turbidites, deposited over the last ~150–200 years. The ~20 ka hiatus in NAC915 includes a 70 cm interval of mud clasts with disordered ages (>45–27 ka), a result of a down canyon mass wasting. Broken shells of shallow shelf foraminiferal species are abundant throughout both cores reflecting the prevalent allochthonous shelf sediments along the deep canyon. Living allochthonous foraminiferal species that were found in surface sediments indicate that sediment transport along this canyon is currently active. These results suggest that the sediment transport and deposition dynamics in the Nahariya canyon, as well as in other blind canyons along the eastern Mediterranean margins, changed during the last deglaciation; from a cumulative regime during the last glacial period to erosive during the Holocene, due to transgression and increasing distance of the canyon head from the coast (source of terrigenous material). During the last two centuries, sedimentation in the canyon resumed, probably as a result of recent large-scale anthropogenic processes (e.g. intense deforestation) that affected the availability, transfer and accumulation of thin sediments.

Theme 13. Provenance of sediments – from source to sink

Special Session 13.3. Quantitative study for source-to-sink system

Oral presentation

Constraints of Triassic provenance and paleogeomorphology on the formation of sedimentary fan groups in the central Junggar Basin

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The distribution of Triassic sedimentary fan groups in the central depression of the Junggar Basin is quite different from that of the well-known gentle slope fan groups in Mahu sag due to the difference of the basin-and-range structure. From the perspective of provenance supply, the central depression is far away from the old mountains at the edge of the basin, and its provenance mainly came from the Carboniferous paleouplift in the north of the basin. From the perspective of the palaeogeomorphic pattern, the northern margin of the central depression developed four nose-like highlands including Xiayan–Dabasong, Shixi, Mobei and Lunan, and four low-lying valleys including Xiayan, Qianshao, Mobei and Dongdaohaizi. The development of fan groups is mainly controlled by palaeogeomorphology. Compared with Mahu sag, the provenance and palaeogeomorphologic characteristics of the central depression determine that its single provenance, stable supply, small fan, thin sand body, and fine grain size. From the comparison of the fan groups in the central depression, the fan bodys developed in Xiayan, Qianshao and Dongdaohaizi low-lying valleys with relatively steep palaeogeomorphology are large, but the reservoir physical properties are poor, while the deposition slope of Mobei low-lying valley is relatively gentle, and the front develops a platform area, resulting in a small fan body, but it is easy to form a reservoir with good physical properties. The characteristics of different fan bodies are clarified, which is conducive to the decision-making and deployment of exploration.

Theme 13. Provenance of sediments – from source to sink

Special Session 13.3. Quantitative study for source-to-sink system

Oral presentation

Mesozoic–Cenozoic multistage tectonic deformation of the Qilian Shan constrained by detrital apatite fission track and zircon U–Pb geochronology in the Xining Basin

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The Qilian Shan on the northeastern edge of the Tibetan Plateau contains structural, sedimentary and tectonothermal records of plateau formation and growth in response to the Indian–Asian continental collision. In this study, we reveal the tectonic deformation evolution of the Qilian Shan by detrital apatite fission track (AFT) thermochronology and provenance analysis of a sedimentary section on the northern flank of the Qilian Shan based on paleocurrent measurements and detrital zircon U–Pb geochronology. The unannealed detrital AFT peak ages span ~154–10 Ma, and the zircon U–Pb ages range between ~3260 Ma and ~ 178 Ma. Detrital AFT ages showing that the initial exhumation occurs ca. 154–135 Ma and ca. 105–81 Ma and abundant ages of ca. 61–24 Ma indicate the prominent exhumation of the sedimentary provenance from the Qilian Shan at those times. Zircon U–Pb analysis suggests that the sediments were generally sourced from the Qilian Shan to the south, with moderate provenance changes at ~10 Ma and 5.1 Ma. These geochronological datasets imply that the Qilian Shan experienced multistage deformation during the Mesozoic–Cenozoic, i.e., late Jurassic–Early Cretaceous (153.6–135.2 Ma), late Cretaceous (104.5–80.9 Ma), late Paleocene–Oligocene (61–43.1 Ma; 38.2–24.6 Ma), mid-late Miocene (10 ± 4 Ma) and Pliocene (5.1–3.6 Ma). During the Cenozoic, the deformation initiated in the late Paleocene reflects the synchronous far-field response of the northeastern Tibetan Plateau margin to the Indian–Asian plate collision.

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Special Session 13.3. Quantitative study for source-to-sink system

Oral presentation

Provenance of Piauí Formation (Parnaíba Basin, Brazil) and effects of hydraulic segregation on heavy minerals assemblage

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The Parnaíba Basin is a large intracratonic basin (600,000 km^2) located in northeast Brazil that registers the sedimentation history during Paleozoic to Mesozoic Eras. Balsas Group deposition (Pennsylvanian to Upper Triassic interval) occurs within arid environment context associated with the 30° latitude arid belt. The Pennsylvanian Piauí Formation, focus of this study, shows aeolian crescent dunes and damp interdune with hyper-concentrated fluvial discharges. This work aims to compare the fluvial and aeolian heavy minerals assemblages to evaluate a possible reworking and hydraulic sorting process. Logging of the fluvial–aeolian strata of outcrops of the Piauí Formation at Floriano area was carried out and channel-fill facies, with planar and tangential cross stratification sandstones, and aeolian dunes dominate. Four samples from fluvial strata and one sample of an aeolian dune were collected. To check the hydraulic sorting along the different grain size classes, we sieved three distinct fractions, larger than 180 µm, between 180–100 µm, and smaller than 100 µm. Quantitative petrography and SEM-EDS analysis reveal a predominance of zircon in the finer grain-size fraction (<100 µm), zircon and Fe-Ti oxides in the 180–100 µm class, and tourmaline and garnet in the coarser fraction (>180 µm). The aeolian sample displays a lower proportion of heavy minerals over light minerals (0.038%) compared to the intermediary fluvial strata (0.141% to 0.069%). The mean heavy mineral grain size remains similar; however, the proportion of Fe-Ti oxides increases over zircon. The basal fluvial sample also shows depletion on heavy minerals proportion (0.014%). The fluvial paleocurrent overall flows from east to west, so the up- to downstream samples display a depletion of coarser heavy minerals (> 180 µm). Based on this preliminary dataset, we inferred that: (1) the hydraulic sorting tends to decrease the coarser heavy mineral proportion along a transect from up- to downstream; (2) the aeolian rework of fluvial strata tends to deplete the ZTR index in favor of heavier oxides.

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Special Session 13.3. Quantitative study for source-to-sink system

Oral presentation

A new quantitative method for provenance analysis based on well logging data

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Provenance analysis is a critical connection between the sedimentary basin and the orogenic belt. Methods such as petrological analysis of clastic rocks, heavy mineral analysis, geochemical analysis, and isotopic dating methods are all based on core analysis. However, core analysis is expensive and limited in quantity. Well logging data are easy to obtain and can reflect much information. Moreover, the logging data has longitudinal continuity, which can record the formation properties continuously. A new quantitative method for provenance analysis based on well logging data is proposed. The new method mainly relies on the assumption that terrigenous clastic rocks are the products of weathering, fragmentation, transport, and deposition of the original rocks in the provenance area, and the composition and combination of clastic minerals in the rocks can reflect the characteristics of the source area. Then, different clastic minerals have different physical properties, and logging responses, so clastic rocks from different provenances may have different logging responses. The difference in logging response can be used to analyze the source–sink system. A case study is introduced. Jiyang Depression of the Bohai Bay Basin is a faulted lake basin in the Paleogene. The northern part of Dongying sag is the Chenjiazhuang uplift, and the western part is the Binxian uplift, both parts are important provenance areas. Sedimentary systems such as near-shore subaqueous fan and fan delta are widely developed in the steep slope zone of the faulted lacustrine basin. The logging and drilling lithology analysis shows that well A has a 50 m conglomerate layer in Shahejie Formation. The logging data show that the logging response of the top 30 m conglomerate layer is different from that of the bottom 20 m conglomerate layer. The core analysis shows that the top conglomerate is dominated by granitic gneiss rock, while the bottom conglomerate is dominated by carbonate rock. two provenance systems are developed in Dongying Sag. This method can achieve good results on coarse-grained sediments, but this method may be restricted to deposits mainly composed of fine sandstone, silty, and shale. In the future, multiple methods should be combined to improve the result of provenance analysis.

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Special Session 13.3. Quantitative study for source-to-sink system

Poster presentation

Exploring the environment hydrodynamics of the Late Cretaceous Szozdy Delta System by the rutile–tourmaline index analysis.

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The middle Campanian Szozdy Delta System, located at the northern edge of the Late Cretaceous Łysogóry–Dobrogea Land in southern Poland, has provided insight into the relationship between the abundance of rutile and tourmaline in deltaic sedimentation. The inverse relationship between these two minerals is referred here to as the rutile to tourmaline index (RTidx). One notable feature of the submarine part of the Szozdy Delta System is the presence of tripartite cyclothems, which consist of three units from bottom to top: calcareous-mudstone, -sandstone, and -gaize (Remin et al. 2022). A clear inverse relationship between tourmaline and rutile can be readily recognized in such defined cyclothems. It is highlighted by the standardized Z-score statistic that provides insight into the relative changes in abundance of these two mineral phases. Both minerals have similar characteristics such as shape (highly rounded) and durability but differ slightly in size and markedly in density – namely 3.03–3.18 and 4.23 g/cm^3 for tourmaline (dravite) and rutile, respectively. Since the weight of the two minerals analyzed differs markedly, it might be expected that these two mineral phases will be strongly dependent, both vertically and spatially, on the local sedimentary environment – and by extension, on the hydrodynamic power that existed during the deposition of successive cyclothems. Simply put, the (lighter) tourmaline will be transported further into the more quiescent prodelta environment, rendering the prodelta facies overrepresented in this mineral phase, whereas the markedly heavier rutile will be deposited closer to the river discharge. Accordingly, when the RTidx ratio increases, the hydrodynamic power in the sedimentary environment increases as well. Such interpretation of the RTidx is supported by additional sedimentological and palynofacies analyses. This research has been supported by the Polish National Science Centre [Narodowe Centrum Nauki, Polska], grant number UMO-2018/29/B/ST10/02947; “Late Cretaceous tectonic evolution of the SE part of the Danish–Polish Trough; revision of the facial architecture and implication for the paleo- and paleobiogeography of Europe”.

References

Remin, Z., Cyglicki, M., & Niechwedowicz, M. (2022): Deep vs. shallow–two contrasting theories? A tectonically activated Late Cretaceous deltaic system in the axial part of the Mid-Polish Trough: a case study from south-east Poland. Solid Earth, 13(3), 681–703.

Theme 13. Provenance of sediments – from source to sink

Special Session 13.3. Quantitative study for source-to-sink system

Poster presentation

Annual riverbed erosion rates in the Lower Danube during the last decade

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Danube River is one of the largest fluvial systems in Europe in terms of length, drainage area, discharge and sediment load. Multiple anthropogenic pressures in the Danube River Basin have led to evident hydromorphological alterations, amongst which the most heavily disturbed component is the sediment regime. Like many temperate zone rivers, the sediment load of the Danube River has been substantially reduced due to the combined impact of flood protection, navigation and hydropower measures applied over a long period of time. In this study, annual changes in riverbed morphology were analysed for a period of ten years (2010–2020) using various data recorded from single-beam bathymetry, river discharge and sediment load measurements. We investigated five reaches located downstream of the Iron Gates I and II Dams, displaying various representative landscapes for the Lower Danube sector such as wide sections with large or small islets, narrow sections or large meanders. The analyses revealed an accelerated riverbed incision compared to previous trends (i.e. 1985–2005 interval) which is discussed in relation to anthropogenic interventions such as dredging for ensuring optimal navigable conditions, floodplain embankment and hydropower generation.

Theme 13. Provenance of sediments – from source to sink

Special Session 13.3. Quantitative study for source-to-sink system

Poster presentation

The influence of wind field on depositional systems in Qinghai Lake, China

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As the manifestation of the activities of atmospheric flow field, wind is an important geological agent, which effects on many depositional systems. Wind not only has the ability of erosion, transportation and deposition, but also can transmit energy and momentum to the water body, and create waves and wind-driven water flow to provide the driving force for sediments transportation in the coastal zone of the basin. Through strengthening the research on the affection of wind field towards the depositional systems, combined with the impaction of other controlling factors, the relationship between the mutual restriction and mutual influence of various sedimentary controlling factors in the modern sedimentation of Qinghai Lake is studied. The study of sedimentology starts from the traditional "unitary" facies model, to the "binary" source–sink system, and then the "ternary" depositional dynamics system by comprehensively considering of wind field, provenance and basin. The development of beach bar is controlled by the wind field, source–sink system, which is a typical product of the comprehensive action of wind, source, landform (including macro geomorphology and micro geomorphology), water depth and other factors. On the plane, the macro palaeogeomorphology determines the favorable development area of beach bar, and the micro palaeogeomorphology affects the local distribution of sand body by changing the Hydro-dynamic energy. On the whole, it is easy for the development of beach bar sand bodies with large area and thickness in the windward area, gentle slope zone, positive terrain, with sufficient provenance, during the transition stage of lake level from decline to rise. The geological prediction model of beach bar is established by using the wind field, and source–sink system, and the major techniques for beach bar prediction are paleo-provenance, paleo-geomorphology, paleo-wind force, paleo-wind direction and paleo-water depth, so as to recover and deduce the evolution and formation of beach bar. The prediction of the developing possibility of beach bar in the area controlled by the non-major provenance area can face to the challenges in thin-interbedded sand body prediction and confirmation during oil and gas exploration.

Theme 13. Provenance of sediments – from source to sink

Special Session 13.4. From river catchments to the deep sea: case studies, applications, state of the art and new frontiers of source-to-sink research

Oral presentation

Links between Quaternary climatic changes and sediment flux recorded in a deep-water active rift basin

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The efficacy of deep-water sedimentary successions as reliable records of environmental change has been questioned. This is because the response time, and distance, to perturbations (e.g. climate, tectonics) in sediment supply becomes too 'shredded' to be used as an archive. To test the links between external controls on sediment flux and the deep-water stratigraphic record, we studied the Gulf of Corinth. This is an active rift basin with steep drainage basins and narrow shelves. This physiography is expected to result in short response times to changes in climate on sediment flux. The confinement of rift basin allows for a complete accounting of sediment volumes. Recent acquisition of high-resolution seismic, IODP cores and robust chronological framework affords evaluation of sediment accumulation rates at high temporal resolution. The study builds on chronological framework established by the IODP 381 science team which involves magnetostratigraphic datum, sea-level curves, and U/Th dates to derive dating of well-defined stratigraphic intervals. Based on multiple paleoenvironmental proxies, the IODP boreholes and key marine-isotope stage (MIS) tie-points can be correlated to distinct seismic facies units.

Therefore, seismic units allowed for quantifying of sediment flux rates into the Gulf for successive glacial–interglacial cycles. Furthermore, seismic-well ties guaranteed by CLSI (core-log seismic integration) has shown phases of glacial–interglacial conditions approximate to alternating high and low-amplitude units on 2D seismic. More broadly, computed isopach maps shows the often-smooth geomorphic transition of the Sythas canyon-incised system allows for an efficient sediment delivery to base of slope fans. By virtue of this short sharp configuration, we see canyons as sustained during all sea-level stands. The study highlight low sensitivity of the canyon-incised system to cyclical sea-level fluctuations. Besides shelf morphology, this leaves hinterland sensitivities, i.e., climate and vegetation type, as the most important controls to 10^4–10^5 cyclical waxing and waning of sedimentation rates.

Theme 13. Provenance of sediments – from source to sink

Special Session 13.4. From river catchments to the deep sea: case studies, applications, state of the art and new frontiers of source-to-sink research

Oral presentation

From flood to turbiditic events: reduced complexity modelling of the Var source-to-sink system

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Turbidity currents are a form of gravity-driven flow that occurs in marine environments. These currents contain a low volumetric percentage of sediment but are very important in transporting particles from the coastal environments to the deep marine. These particles can be of organic matter, leading to blooms in life at the margins of the oceans. The particles can also be microplastics, where turbidity currents transport microplastics to their eventual deposition within mixed contourite drift deposits. Turbidity currents could therefore be a conveyor belt of pollutants to the marine environment. In the Var sediment routing system, southern France, there is a history of turbidity currents formed by submarine landslides and flooding of the Var River. In the year 2006 there was continuous monitoring of the marine section, where four turbidity current events were recorded. To explore the connectivity between the terrestrial source to marine sink we linked two reduced complexity models of sediment transport and landscape change. The landscape evolution model Caesar–Lisflood was used to model discharge and sediment yield. The flow of turbidity currents and their deposition were modelled with CATS. From calibration of the two models against observations of discharge and suspended sediment in the Var River system we find that in 2006 two rainfall events would have led to hyperpycnal flow and the creation of turbidity currents. These two events match well with two of the four recorded events. Focusing on the largest event we find that the source pulse of sediment from the terrestrial environment is short lived, less than half a day, but contains a significant quantity of fine particles. From the sink end, around 500,000 m^3 of suspended sediment is needed to match the flow event duration and sedimentary deposits. From the source end, the best fit model releases around 400,000 m^3 of suspended sediment. Given the simplifying assumptions behind both models, we find that the source-to-sink comparison is surprisingly good. This study demonstrates the potential of applying reduced complexity models to estimating the transport of particulate pollution from the terrestrial to marine environment, and the inversion of turbidite deposition to understand the full dynamic range sediment routing system response to catastrophic flooding.

Theme 13. Provenance of sediments – from source to sink

Special Session 13.4. From river catchments to the deep sea: case studies, applications, state of the art and new frontiers of source-to-sink research

Keynote lecture

The Early Cretaceous continental-scale McMurray sediment routing system

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The Early Cretaceous McMurray Formation is a succession of fluvial deposits that accumulated in the Mesozoic foreland basin of Alberta, Canada. McMurray strata suggest a Mississippi- to Amazon-scale river system, with laterally amalgamated 25–40 m thick point-bar sands that represent the primary reservoir for the Alberta Oil Sands. This presentation reconstructs the McMurray's sediment-routing system based on ~20,000 detrital zircon (DZ) U-Pb ages from McMurray deposits in Alberta and from time-equivalent fluvial deposits in the Rocky Mountains and midcontinent regions of the United States. McMurray deposits in Alberta display three statistically distinct DZ U-Pb provenance signatures. The first dominates the axial south-to-north McMurray in the Cold Lake area of east–central Alberta, and is dominated by Paleozoic and Meso-Proterozoic age groups that were ultimately derived from the Appalachian Cordillera of the eastern United States, with a minor contribution from the Mesozoic Western Cordillera magmatic arc in the US as well. The second is present in the Ft. McMurray area 300 km farther north, and is dominated by Paleo-Proterozoic and Archean age groups from the Canadian shield. The third defines a tributary-trunk stream relationship, also in the Ft. McMurray area, and consists of an approximately 50–50 mix of south-derived populations from the United States, and east-derived populations from Canada. Interestingly, the south-derived McMurray DZ U-Pb age distributions from Cold Lake are also statistically indistinct from the DZ U-Pb age distributions of age-equivalent fluvial sandstones in southwestern Kansas and the South Dakota Black Hills, in the southcentral and northcentral US, respectively. We interpret this similarity to indicate a fluvial system that was contiguous over a north-to-south distance of ~2000 km. DZ U-Pb data also indicate that sediments for this axial system were derived from the Appalachian Cordillera to the east (~40% of the total), and from the Mesozoic Western Cordillera in the western US (~60%). We conclude that McMurray fluvial deposits represent a continental-scale fluvial system, the Mississippi or Amazon if its time, with a ~$6{*}10^6$ km^2 catchment, headwaters that extended from the SW to SE US and north to the Canadian shield, and channels with bankfull depths of 25–40 m.

Theme 13. Provenance of sediments – from source to sink

Special Session 13.4. From river catchments to the deep sea: case studies, applications, state of the art and new frontiers of source-to-sink research

Oral presentation

The Last Glacial Maximum sequence of the Apennine–Adriatic system: new perspectives on offshore groundwater exploration by integrating source-to-sink analysis and sequence stratigraphic concepts

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Groundwater reservoirs stored in the subsurface of the sea floor represent an offshore natural resource whose spatial distribution can be predicted using sequence stratigraphic concepts in a source-to-sink perspective. Based on high-resolution, onshore to offshore correlation along selected catchment–shelf transects of the Apennine–Adriatic system, the stratigraphic architecture of the Last Glacial Maximum depositional sequence was reconstructed, with a main focus on the lowstand systems tract (LST). Genetically related, fluvial to shelf-edge depositional systems that accumulated between about 32 and 14 kyr BP reveal strong potential for significant storage and recharge of (alternative) offshore groundwater resources. Calibration of seismic data with sedimentological information from boreholes enabled identification and mapping of lowstand strata, from buried paleovalley systems (onshore sectors) downdip into the basin. Amalgamated fluvial gravel bodies show lateral transition to deltaic systems, with an overall progradational to aggradational stacking pattern. As a whole, LST rests above an erosional surface of regional extent (sequence boundary), and shows remarkable areal extent (>5,000 km^2) and an average thickness of 10 m. Above the coarse-grained LST succession, a mud-dominated sedimentary wedge made up of estuarine to marine deposits records the interplay between sea-level changes and fluvial inputs in the last 14 kyr. This wedge exhibits characteristic retrogradational to progradational geometries that include the transgressive systems tract (TST) and the highstand systems tract (HST). A model of sediment provenance and transport pathways in the multi-sourced Adriatic sediment-routing system was built using geochemically unique catchment lithologies as compositional end-members. Provenance shifts across fluvial, coastal, shelf and deep-marine sediments were used to identify the key stratigraphic surfaces and provide constraints to reservoir geometry. Lithologic characteristics, lateral extent and continuity to the onshore aquifer make the LST as a potential aquifer stored in the Adriatic shelf. The overlying muddy TST and HST may work as a seal, thus preventing sea-water intrusion, and making the LST as a strategic offshore groundwater reservoir.

Theme 13. Provenance of sediments – from source to sink

Special Session 13.4. From river catchments to the deep sea: case studies, applications, state of the art and new frontiers of source-to-sink research

Oral presentation

Integrated dam sediment management, a South African case study on enhancing water security

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South Africa is experiencing the harsh effects of climate change, with some impacts manifesting in extreme weather events impacting both water availability and quality. A decline in the number of rainfall days in the last 10 years is masked by rainfall intensity fluctuations. Unpredictable rainfall, soil erosion, and floods have exacerbated dam sedimentation. South Africa is heavily reliant on water stored in dams for its supply and provision. Sediment is transported by rivers into dams. As sediment builds up in dams, it is trapped in reservoirs, and it interrupts the continuity of sediment transport through rivers, resulting in loss of reservoir storage and reduced usable life. This deprives downstream reaches of sediments essential for channel form and aquatic habitats. Dam construction alters sedimentation patterns, disturbs aquatic life, increases deforestation, leads to ecological disproportion, and progresses sedimentation which results in ecosystem degradation. With the acceleration of new dams' construction globally, these impacts are increasingly widespread.

A pragmatic holistic approach to mitigating and managing the effects of sedimentation in dams and catchment areas, is imperative. This research study developed a framework to improve sedimentation management and increase dam storage capacity for increased water security. The research considered the dam, river, and catchment area as a linked ecosystem and this integrated approach, improves sediment management and enables healthy water ecosystems by focussing on the source, transfer and sink zones in the sedimentation process.

The methodologies applied consisted of numerical modelling, ground truthing, data analysis and interpretation. Through these methodologies a storage sustainability scoring tool and a dam catchment operations model to be used in dam infrastructure and ecological projects were developed. Through using the tool, dams can be classified with regards to sediment risk and mitigation interventions are then identified using the model. This enables a systematic approach to managing water resources sustainably for effective decision-making on sediment management and the design of new dams.

Theme 13. Provenance of sediments – from source to sink

Special Session 13.4. From river catchments to the deep sea: case studies, applications, state of the art and new frontiers of source-to-sink research

Oral presentation

Triassic sediment routing system as a tool for plate tectonics reconstructions.

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Opening of the Arctic Ocean is the topic of much debate, and the placement of terranes in the Early Mesozoic remains an open discussion. The Triassic deposits in the Greater Barents Sea Basin (GBSB) were derived from a large catchment called the Eastern Source (Urals and West Siberia), show particular detrital zircon spectra and petrological characteristics, and prograded into and beyond the GBSB in the Late Triassic. The goal of this study is to test the hypothesis of long-distance transport from the Urals and West Siberia into the Arctic basins (Sverdrup Basin, Western Chukotka Basin and North Slope of Alaska) and demonstrate how an understanding of sediment routing can improve pre-breakup plate tectonic reconstructions. In this study, we 1) estimated sediment volumes generated in the Eastern Source in the Late Triassic; 2) estimated the basin geometry in the Late Triassic of the Arctic using published stratigraphy and plate tectonic reconstructions; 3) calculated how far into the Arctic basins the sedimentary system fed from the Eastern Source could have prograded based on 1 and 2; 4) created a model for the distribution of deposits from different sedimentary environments in the Arctic based on points 1–3; and 5) verified the calculated distribution of sediments using new and published detrital zircon age spectra. We revised the Triassic lithostratigraphy, sediment supply patterns and compiled detrital zircon spectra for the Triassic of the Arctic sedimentary basins. Results show that the Eastern Source signature was found in detrital zircons across all basins in the Carnian and the Norian, which implies the Arctic basins were closely connected and the Eastern Source dominated the Arctic basins in the Late Triassic. We show how the reconstructed Arctic sediment routing system constrains plate tectonic models and offer new plate tectonic and paleogeographic reconstructions based on this.

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Special Session 13.4. From river catchments to the deep sea: case studies, applications, state of the art and new frontiers of source-to-sink research

Oral presentation

Hydroclimate controls on S2S sediment transport: integrating ancient, modern and experimental data

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Current understanding of rivers, prominent since the 1960s, emphasizes the role of landscape drivers in determining river streamflow, sediment yields and river geomorphological responses. Climatic drivers are simplified to mean annual temperature or mean annual precipitation. River streamflow is reduced to bankfull or mean annual discharge, or simply scaled to catchment size. Despite many advances in understanding the landscape controls, this paradigm leads to a conceptual oversimplification that is insensitive to climatic drivers, limiting our ability to predict river sediment transport, but also floods and their hazards, and how rivers adjust to climate change. Integrating ancient, modern and experimental data, here we explore how hydroclimate affects river discharge characteristics, and how that in turn alters sediment transport and river responses. Understanding streamflow and sediment transport, is an inherently complex interdisciplinary problem, since they are determined by interactions between climate, landscape and humans, and potentially non-linear river responses that function in feedback loops. The current paradigm assumes that rivers experience frequent small floods and rare large floods, leading to negative (balancing) feedbacks and channel restoration. Here we show that only some rivers have these assumed frequency–magnitude relationships. In many rivers channel recovery may be virtually non-existent and large floods may leave permanent and formative imprints on landscape – experience cumulative flood effects and positive feedbacks. We further show how such differences are linked to river discharge patterns and hydroclimate, and how they affect source to sink sediment transport.

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Special Session 13.4. From river catchments to the deep sea: case studies, applications, state of the art and new frontiers of source-to-sink research

Oral presentation

Modern sediment accumulation and budget in the South China Sea

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The South China Sea (SCS) is the largest marginal sea in the Northwest Pacific. The sediment accumulation and budget in this area have always been the pivotal issues. The muddy areas, modern sedimentation rates and budget are showed for the first time in the SCS based on grain size and smear identification data of 9090 surface sediment samples, ^{210}Pb data from 408 sites, AMS^{14}C data from 112 sites and time-series sediment trap observation data from 33 sites. We identify 8 muddy areas with sediments mainly composed of fine-grained fractions in the coastal and shelf areas. The modern sedimentation rate is the highest in the delta area, reaching > 10 cm/a, which is basically > 0.2 cm/a in the shelf muddy deposition area and upper continental slope connecting the submarine canyon. In the sandy and gravel areas, there is little modern sedimentation, and even erosion appears. The average Holocene sedimentation rate in the deep-water area of the SCS is ~17 cm/ka. It is > 25 cm/ka in the northern, western, and southern continental slopes, 3–8 cm/ka in the eastern island slope, roughly <5 cm/ka in the Xisha Islands, Zhongsha Islands and Nansha Islands, and basically < 3 cm/ka in the deep-sea basin. Approximately 1191.1 Mt sediment accumulate in the subaqueous delta and continental shelf muddy areas of the SCS each year. There are about 161–239.4 Mt/a and 16.5–20.1 Mt/a in the continental slope and the deep-sea basin, respectively, which account for more than 98% of the total sediments. Rivers contribute more than 80% of the sediments in the SCS, atmospheric deposition contribute < 2%, and the rest come from coastal/seafloor erosion and biogenic materials.

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Special Session 13.4. From river catchments to the deep sea: case studies, applications, state of the art and new frontiers of source-to-sink research

Oral presentation

Quantitative (3D) seismic stratigraphy of the Hammerhead shelf margin, southern Australia: Insights into stratigraphic architecture, shallow-marine processes, and deep-water sand delivery

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Shelf margins represent a crucial area along source-to-sink systems where sediments are partitioned from the shelf to slope and basin-floor areas. Reconstructing the evolution of these depositional systems is key for interpreting the interplay between past accommodation and sediment supply and sediment dispersal mechanisms into deep-water areas. In the Bight Basin, on the southern margin of Australia, the Hammerhead shelf margin prograded during the Late Cretaceous following continental rifting from Antarctica. This understudied interval offers important insights into source-to-sink processes in a post-rift, greenhouse, high sediment supply setting. A dynamic stratigraphic approach using high-resolution 3D seismic data across the Hammerhead shelf margin was used to quantitatively characterise 28 paleo-shelf margins developed over ~1.9 Myrs (each with duration of ~67 kyrs). By applying a shallow-marine process-based classification to paleoshorelines alongside quantitative analysis of the architecture of their coeval deep-water deposits, statistical relationships and clear links between shallow marine processes, stratigraphic architecture, and deep-water sand delivery are revealed. A statistically significant relationship between fluvial-dominated shorelines, higher slope gradients, and mass transport deposit deposition is demonstrated, as is a requirement for fluvial influence at the shoreline for the development of long runout turbidite systems. In addition, these long runout turbidite systems are interpreted to have formed due to repeated density flows leading to greater sediment transfer efficiency and more sediment being supplied. This research has direct application to improve prediction of reservoir locations within the Bight Basin for resource exploration and/or carbon sequestration and may also be applied to improve deep-water sediment predictability in other basins worldwide developed in similar tectonic and climatic settings.

Theme 13. Provenance of sediments – from source to sink

Special Session 13.4. From river catchments to the deep sea: case studies, applications, state of the art and new frontiers of source-to-sink research

Oral presentation

Sediment source to sink process and its controlling mechanism in Asian continental margin

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As the largest continental margin in the world, the Asian continental margin (AM) is under the influence of the strongest land–sea interaction and the most frequent exchanges of material and energy. The rivers in the AM contribute about two-thirds of the global fluvial sediments to the ocean, which has a great impact on the sedimentation, biogeochemical processes and marine ecology of the marginal seas and the global oceans. Through international cooperation during the past 20 years, we have systematically carried out sedimentological investigation from the East Siberian shelf in the north to the Bay of Bengal in the south of the AM. Based on these data, we compiled a 1:3.000,000 sediment type map of the AM and several 1:1.000,000 sediment type maps of the key areas, and elaborated the distribution pattern of sediments; We established a set of effective provenance proxies to elucidate the properties of fluvial sediments, identified the sediments provenance in the Gulf of Thailand, Andaman Sea, Bay of Bengal, South China Sea, Sea of Japan, Sea of Okhotsk and East Siberian Sea, described the processes of transportation and deposition of fluvial sediments in the ocean; We clarified the sediment source to sink processes and controlling factors in the marginal seas within different latitudes and established the sedimentation model; The source, input and burial of organic carbon on the shelf at different latitudes and their response to natural processes and human activities have been quantitatively evaluated; The mechanisms controlling the sediment source to sink process, driven by the Asian monsoon, sea-level change, uplift of Tibetan Plateau, ocean current and sea ice, were revealed.

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Oral presentation

Paleogeographic response to dynamic uplift in Shetland – constraints from Paleocene sediment fluxes and stratigraphy

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In the Paleocene North Sea, peaks in sediment flux and correlated hinterland uplift have been associated with dynamic topography created by a precursor to the Icelandic Plume. However, the influence of source-area tectonics and climate on the regional paleogeographic evolution is less understood. Here, we investigate the paleogeography of the East Shetland Platform in terms of the extent and timing of erosion vs deposition and how these can be used to reconstruct changes in dynamic topography. The stratigraphic record of the area was interpreted using >60,000 km^2 of 3D seismic data and c. 300 well-logs, used to calculate sediment fluxes and to construct multiple chronostratigraphic diagrams and high temporal resolution paleogeographic maps. Multiple episodes of relative sea-level fall and basinward offlap advance are recorded during the Paleocene. From Late Thanetian–Ypresian, five unconformity-bounded sequences are marked by prograding clinoforms of the Dornoch Formation. Temporal and spatial changes in the distribution of depocenters and unconformities indicate strong variability in patterns of shelf accommodation/erosion and fan deposition. Variability results from the interplay between laterally-uneven RSL fall, time-varied sediment entry point distribution, along-shore sediment transport and inherited topography. Unconformities and paleogeographic maps also suggest a first-order control on erosion and sediment distribution promoted by the transiently and differentially uplifted topography of Shetland. Two peaks in sediment fluxes are observed: one related to the deeper water Lista Fm. (Selandian–Thanetian) and one related to the Upper Dornoch Fm. (Ypresian). The first peak matches the longer-term modelled dynamic topography of the Icelandic Plume, while the second peak may be tied to the Paleocene–Eocene Thermal Maximum or to a simultaneous, transient uplift event recognized across West and East Shetland. However, fluxes are very sensitive to the age intervals assigned to each unit, something that particularly affects the shorter-lived Upper Dornoch peak. Ultimately, results indicate shorter-wavelength spatial and temporal variations in uplift than what is typically assumed for dynamic topography, perhaps as a result of additional modulation by lithospheric structures.

Theme 13. Provenance of sediments – from source to sink

General Session

Oral presentation

Cretaceous mafic magmatism as revealed by sedimentary provenance analysis in the Putumayo Basin, Colombia: implications for the regional tectonic evolution

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The Cretaceous System of the Putumayo Basin (Colombia) comprises Aptian–Albian clastic deposits and Albian–Santonian clastic/calcareous rocks, both elements of Petroleum Systems in the basin. The Cretaceous System accumulated unconformably on top of a Triassic–Jurassic failed rift, in a retro-foreland basin setting at the NW margin of South America. Previous works have reported Cretaceous mafic volcanism in the Albian–Santonian series in the Oriente Basin (Ecuador), which is the southern extension of the Putumayo Basin, and documented migration of the volcanism from its northern border (ca. 110 Ma) to the SW (ca. 82 Ma). The presence of olivine in heavy mineral separates from fine-grained sandstones and siltstones of the Aptian–Albian series in the Putumayo Basin, is a good indicator of provenance from ancient mafic igneous and/or mantle-related rocks, but also from active mafic volcanism. Furthermore, due to the chemical instability, detrital olivine indicates that the chemical weathering was limited at that time. In contrast, volcanic-derived olivine crystals indicate minimal diagenetic overprint in the basin. We interpret the olivine crystals as derived from mafic volcanism and/or basalts, as previously documented in the adjacent Oriente Basin. Our findings suggest that the mafic magmatism started earlier in the Putumayo Basin in the early Albian or before, and progressively migrated to the southern Oriente Basin (Ecuador). This interpretation is supported by the presence of olivine in the Aptian–Albian series in the Putumayo Basin, while basaltic tuff cones are documented in the Albian–Santonian series in the Oriente Basin. This observation agrees with the N–S migration pattern of the age of the mafic bodies into the Oriente Basin. Moreover, we interpret the Cretaceous magmatism in the Putumayo Basin associated with basaltic intraplate magmatism, probably sourced by decompression partial melting of the upper mantle, triggered by subduction abandonment and subsequent slab roll-back, as previously suggested to explain the Cretaceous mafic magmatism in the Oriente Basin. Ultimately, we show that sedimentary provenance analysis provides important evidence to understand the tectonostratigraphic evolution of one of the most prolific hydrocarbon basins in northern South America.

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General Session

Oral presentation

Multi-technique provenance analysis of the Palaeogene aeolian dust deposits at Ulantatal, Inner Mongolia, China

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Understanding atmospheric circulation and atmospheric mineral dust in the geologic past during various global climate states is crucial for building future climate scenarios. As an important, yet poorly understood component in the Earth system, mineral dust links the atmosphere to geosphere and both affects and is affected by changes in climate. Various studies have shown that variation in Central–East Asian dust emission, transport and deposition are linked with global climate changes. Provenance studies of the aeolian dust deposits on the Chinese Loess Plateau (CLP) and adjacent regions provide essential information to reconstruct past Central–East Asian atmospheric circulation and to understand the evolution of regional aridity and dustiness since the Eocene. In this study, we present multi-technique provenance data from an unusually old terrestrial loess sequence from the Palaeogene (c. 35–27 Ma) of Ulantatal in Inner Mongolia, China, approx. 400 km northwest of the central CLP. We apply detrital zircon U–Pb ages, detrital rutile geochemistry, whole rock Sr and Nd isotopic analyses, and anisotropy of magnetic susceptibility. We also quantify the contribution of different potential source areas by using an (un)mixing model for detrital zircon age data. The preliminary results indicate a relatively constant dust source during c. 35–27 Ma, including through the major Eocene–Oligocene global climate transition. The dominating dust transport trajectory was from the northwest, consistent with previous suggestions of a resilient East Asian winter monsoon since the Palaeogene despite palaeogeography changes. Comparison to Palaeogene dust deposits on the southwestern CLP also reveals a similar spatial variability of dust provenance as recorded in the Neogene and Quaternary CLP dust.

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General Session

Oral presentation

Sedimentary evolution and controlling factors of beach bar sand bodies: a case study of Neogene in Zhahaquan Area, western Qaidam Basin

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In order to further evaluate the oil and gas exploration prospect and predict the favorable exploration zone and target of the beach bar sand bodies which developed in the shore–shallow subfacies in the Upper Ganchaigou Formation in Neogene in Zhahaquan area, western Qaidam Basin, based on the core observation and comprehensive analysis of drilling and logging data, combined with the analysis results of rock thin sections, cumulative particle size probability curves, dark mudstone mud-to-ground ratio and sand-to-ground ratio sensitive parameters, the development and evolution characteristics of shore–shallow lake beach–bar sand bodies and paleogeomorphology in the Upper Ganchaigou Formation in this area are studied in detail. It is considered that the development and evolution of beach-bar sand bodies in Zhahaquan area is mainly controlled by the development and evolution of paleogeomorphology. The results show that: (1) The braided delta–shallow lake sedimentary system was developed in the Upper Ganchaigou Formation in Zhahaquan area. The beach bar sand body was developed. (2) the development scale of beach bar sand body in the study area first increased and then decreased. From the early to the middle period, the development scale of beach bar sand body continued to increase. From the middle stage to the late stage, the development scale of beach bar sand body decreases continuously. (3) The study area paleogeographic background of high in the west and low in the east, low in the north and low in the south, and high in the middle part. (4) Comprehensive analysis shows that the development and evolution of beach bar sand body of the Upper Ganchaigou Formation in Zhahaquan area is controlled by the source scale and the development and evolution of micropaleogeomorphology. Among them, the development and evolution of micropaleogeomorphology is the main control factor for the development and evolution of beach bar sand body.

Theme 13. Provenance of sediments – from source to sink

General Session

Oral presentation

Constraining the timescales of intermediate sediment storage and refining sediment routing

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Transient sediment storage and recycling (e.g., burial and uplift) are ubiquitous processes in clastic sedimentary systems. These processes can be qualitatively demonstrated using petrography or geochemistry. However, the absolute timescales of sediment storage and recycling are often poorly constrained despite being important in the development of accurate source-to-sink models. A major limitation in determining the durations of sediment storage and recycling is the scarcity of dateable minerals able to provide absolute age constraints on the rates of associated processes (e.g., intermittent burial). This study presents geochronological and geochemical data on xenotime outgrowths on detrital zircon grains from the Early Cretaceous Broome Sandstone in Western Australia. The U-Pb ages of xenotime outgrowths are at least 150 Myr older than the depositional age of the Broome Sandstone, indicating that they were transported along with their zircon substrate. The findings of this study contrast with previous assumptions on the fragility of xenotime outgrowths (and hence the interpretation of an authigenic origin), but instead offers a new potential in tracking intermediate geological processes along the source-to-sink pathway. Integration of geochronology and geochemistry has revealed a correlation between the growth of xenotime outgrowths and known geological events in the source area of the Broome Sandstone detritus. In tandem with detrital zircon U-Pb ages these results can be used to reconstruct complex mixed phase grain histories, clearly demonstrating transient sediment storage and recycling of detrital zircon in specific sedimentary basins rather than first-cycle routing from crystalline basement. The multi-cycle origin of part of the detrital zircon cargo aids in refining the source-to-sink reconstruction of the Broome Sandstone detritus. Ultimately, such temporal information on sediment storage and recycling derived from coupled xenotime–zircon analysis are typically not recorded by conventional provenance methods and are expected to be of significant use in holistic provenance models.

Theme 13. Provenance of sediments – from source to sink

General Session

Oral presentation

New sedimentological data from the Okavango wetlands (Botswana): and endorheic sink for microplastic particles of the Cubango Okavango River Basin

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The Cubango–Okavango River Basin (CORB) feeds a large endorheic delta with one of the most pristine wetlands on the planet, the Okavango Delta in Northern Botswana. This study presents an overview of the sediment production and distribution system in the CORB, and aims at expanding the current knowledge of anthropogenic impact on the Okavango Delta. Here, together with detailed characterization of surficial sediments from the CORB, we present the first results of MP sediment concentrations for the upper Okavango Delta (Panhandle), considered as a major sink for most of the anthropogenic pollutants in the basin. At the upstream end (Mohembo), discharge varies between 100 $m^3 s^{-1}$ during low flow and 700 $m^3 s^{-1}$ during peak flow (March–April). Sediment samples were collected at 20 sites across the CORB for the characterization of sediment variability in the system. An additional 7 sites were targeted in the Panhandle, between Mohembo and Sepupa, for a preliminary assessment of the MP content in Delta sediments. Samples were collected by scooping from active channels, point bars and oxbow lakes. Grain size distribution is decreasing from 0.5 mm to 0.3 mm moving downstream with virtually no components < 0.15 mm. The average organic matter content in the sands is always below 1%. Fluorescent microscopy showed MP sediment concentrations from around 57 MP/kg dry weight in some of the oxbows to 400 MP/kg in the main channel. About 92% of the identified MP were classified as fragments, varying in length between 64 and 1065 μm. The remainder of the particles was identified as fibres. Raman Spectroscopy revealed that the composition of the MP is dominated by polyethene terephthalate (PET), polypropylene (PP), polyethene (PE), polystyrene (PS), and polyvinyl chloride (PVC). Overall, abandoned meanders have less MP than the active channels, and no MP were found entangled in the papyrus roots that cover most of the floodplains. From this novel data set it was possible to estimate that 10.9–336.2 billion particles could be annually transported into the Okavango Delta, indicating that the region represents a significant sink for MP, raising concerns for the unique wetland ecosystem. Future studies will focus on determining basin-wide MP distribution and their relation to sediment transport patterns.

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General Session

Oral presentation

The physical abrasion of plastic to form microplastics: an experimental approach

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Secondary microplastics (MP) are particles that result from the breakdown of larger plastic items in the environment through chemical degradation and/or physical abrasion. Weathering via UV exposure has been well studied, but much less is known about abrasion and how this results in fragmentation and MP generation. The aim of this research is to explore the physical abrasion of commonly littered plastic polymers: Polystyrene (PS), Polypropylene (PP), Polyethylene Terephthalate (PET) and High-density Polyethylene (HDPE). We tested the hypotheses that plastic items can generate microplastics through physical abrasion processes alone, whether plastics of different compositions generate MP at different rates and sizes; and whether exposure to UV light prior to physical abrasion effected MP generation rates. Laboratory experiments were designed with carefully controlled variables, using tumblers with a polymer and either water (control) or water and gravel. At sampling intervals of 2, 22 and 112 days, 7 pieces of polymer were removed, photographed, accurately weighed and examined for 3D textural analyses with an Infinite Focus Microscope. Identical experiments were conducted after exposure of each polymer type to the equivalent of 1 year of UV light in Florida. Results demonstrate that after 112 days of tumbling with gravel present there is a significant weight loss in all polymers, both in pristine and pre-weathered samples, compared with the control (two-tail t-test, $n=7$, $p<0.05$). All pre-weathered polymers, except PP, lost significantly more mass than the correspondent pristine polymers (two-tail t-test, $n=7$, $p<0.05$). This highlights how pre-weathering can influence subsequent fragmentation of polymers by abrasion. Comparison across polymer compositions demonstrates that PET (both pristine and pre-weathered) lost significantly more mass than the other polymer types at 112d with gravel (two-tail t-test, $n=7$, $p<0.05$). These preliminary results show that MP can be produced by abrasion without prior exposure of polymers to UV light and how weight loss increases significantly when polymers have been previously exposed to UV light. This experimental approach can provide useful insights on abrasion processes and microplastic fragmentation and how MP can become part of the sediment cycle.

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General Session

Oral presentation

Provenance record of paleo-drainage evolution in the Zagros–Makran Transition Zone: linking from source to sink

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The transition zone between Zagros Orogen and Makran accretionary prism is a significant region that reflects how these were connected. To investigate the provenance record of Neo-Tethys subduction–collision, we have used sandstone modal analysis, U–Pb age, and rare earth element compositions of detrital zircons, from Late Mesozoic to Cenozoic sandstones. Sandstone modal analysis yielded different lithic grain assemblages in the litharenites through time and space. The U–Pb age spectra of the detrital zircons show major picks from Cenozoic to Mesozoic in the Eocene (30–50 Ma), Late Cretaceous (80–100 Ma), and Jurassic (155–180 Ma). Most zircons originated from the continental magmatic source, and Late Cretaceous zircons indicate a MOR source based on their geochemical compositions. The results indicate that the Zagros–Makran transition zone has received a mixing source from Makran accretionary prism and Zagros Orogen since the Oligo-Miocene. This time is probably related to the collision of Arabia and Eurasia along the Zagros at the northwest of the transition zone. As a result of progressive deformation from NE of the Inner Makran (Bashakerd Thrust) to the SW, the sediments recycled to the east of the Minab–Zendan Fault from the Late Miocene. Therefore, our result shows that the filling up of the space in the transition zone started from the Oligo-Miocene, and progressive deformation and recycling are continuing along the Minab–Zendan fault to the south.

Theme 13. Provenance of sediments – from source to sink

General Session

Oral presentation

Provenance of Upper Carboniferous sediments in the western Taebaeksan Basin, Korea: tectonic implications

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The Sino–Korean Block (also called the North China Block) and the South China Block significantly differ not only in their Precambrian basement but also in their Paleozoic strata deposited before their Triassic collision. The Qinling–Dabie–Sulu Belt in China marks the suture zone between the two blocks, but its eastern extension around the Korean Peninsula has long been disputed. The Paleozoic stratigraphy of the Taebaeksan Basin (TB) in the central eastern Korean Peninsula is similar to those of the North China basins, which is widely accepted as one of the key pieces of evidence that the TB was a part of the Sino-Korean Block during the Paleozoic. However, since the Cambrian–Ordovician strata distributed in the western TB (Yeongwol Group) are somewhat different from those distributed in the eastern TB (Taebaek Group), there have been opinions that the western TB belonged to the South China Block or existed as a separate microcontinent. This study aims to resolve this issue by focusing on the upper Carboniferous strata that unconformably overlie the Cambrian–Ordovician succession in the western and eastern TB. Petrographic, geochemical, and detrital zircon U–Pb analyses were conducted on the sandstone and mudrock samples from the western TB. The results show that the provenance characteristics of the upper Carboniferous sediments in the western TB (Gapsan and Yobong formations) are highly similar to their equivalents in the eastern TB (Manhang Formation), suggesting a shared provenance in the same tectonic setting. Two possibilities are thus raised: 1) the western and eastern TB were not distant in the first place; 2) they were brought together in the middle Paleozoic. The former interpretation is favored in that there is little evidence of magmatism/metamorphism supporting the latter.

Theme 13. Provenance of sediments – from source to sink

General Session

Oral presentation

Use of heavy minerals as provenance indicator in fluvial successions of Paleo–Mesozoic Pranhita–Godavari Gondwana Rift Basin, India

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This study examines Permo–Carboniferous to Cretaceous Gondwana succession in the Pranhita–Godavari Basin in central India to track the source of sediments. The succession mostly comprises fluviatile deposits of sandstones, mudstones, and a few freshwater carbonates along with continental fossils. The study aims for palaeogeographic reconstruction, and to determine the parent rock of Gondwana sediments, based on major and heavy mineral studies of sandstone. Mineral chemistry of garnet and rutile and monazite dating was carried out to precisely track the source of sediments. Petrographically these sandstones are mostly feldspatho-quartzose and quartzose. The Qm–F–Lt triangular diagrams infer that the sandstones of this basin were derived from transitional continental and craton interior. (Fe + Mn)–Mg–Ca garnet triangular plot indicates the predominance of granulite and amphibolite lithologies in the source areas. The ratio of Cr to Nb in rutile suggests that sediment input from metapelites as the predominant source. The entire spectrum of monazite detrital ages from the Pranhita–Godavari Gondwana basin can be grouped into three major clusters: (1) 400–970 Ma, (2) 1200–1300 Ma, and (3) 2000–2600 Ma. The obtained monazite ages indicate that the whole of PG Gondwana successions deposited sediments in the ranges between Ca. 390–2600 Ma (Devonian–Paleoproterozoic). Based on the correlation of source compositions, monazite geochronology, and available paleocurrent data, the majority of these Gondwana sediments were derived from the Karimnagar granulite belt, Khammam schist belt and the Eastern Ghat mobile belt, situated to the east and southwest parts of the Gondwana succession. The rocks of Pan-African orogeny, situated to the west side of the basin, were a minor contributor to the Gondwana sediments of this basin.

Theme 13. Provenance of sediments – from source to sink

General Session

Oral presentation

Nile river – regional paleogeography, stratigraphy and paleo-drainage reconstruction (Eocene–present) and its implication to the hydrocarbon exploration

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Nile River, rises south of the Equator and flows northward through NE Africa to drain into the Mediterranean Sea. It is the longest river in the world, of about 6,650 km and drains an area estimated at 3,349,000 square km. The Nile is formed by three principal streams: the Blue Nile, the Atbara, which flow from the highlands of Ethiopia, and the White Nile, the headstreams of which flow into Lakes Victoria and Albert. There are at least two paleogeographical models; 1st, Nile did not connect from Ethiopia, Eritrea and Sudan through to the Mediterranean until at earliest Late Messinian times and, for some authors, not until the Holocene. 2nd, Blue Nile and other Ethiopian tributaries originated in the Oligocene and follow varying courses through Sudan and Egypt to reach the current outlet, suggesting an easterly course in Egypt during the Oligo-Miocene along the Qena valley and others a more westerly course. The Present-day Nile river system demonstrates strong climatic and topographic controls, with over 90% of current sediment originating from the seasonally wet Ethiopian rift shoulders. This sediment is very shale-prone as the eroding material consists largely of trap basalts. Particularly wet phases include the Early Pliocene, when sedimentation rates in the Nile Cone were at a maximum. Examination of outcrop geology would predict that wet-phase sediment would be more sand-prone than during dry periods, with more erosion of the on the way, granitic material on the Red Sea rift shoulders and of the outcropping Nubian sandstone within southern Egypt and Sudan. There is a total volume compacted sediment of 5.74×10^5 km^3 in the Delta cone. Sedimentation rate has been driven by hinterland evolution from Oligocene till now, in terms of tectonics, climate, drainage and lithology. The fission-track ages measure imply, that average of 1500m overburden have been removed since Oligocene. Hydrocarbon fields are proved within the fluvial and deltaic channels, shallow marine, incised valleys and slope turbidites, at all levels within the Nile Delta area (from Mz until Pleistocene). The Delta area has a gas reserve of roughly 230 TCF spread across over 126 gas fields in the cone.

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General Session

Oral presentation

Danubian sediments from Alpine–Carpathian en route to the Black Sea: a geochronological, lithological and geomorphological source-to-sink approach

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The Danube River basin covers a several tectonic units, orogens and platforms; hence, its tributaries contain a significant sedimentary diversity. The analyzed Quaternary sediments from the Lower Danube River and several left tributaries bring up-to-date strong evidence of the most eroded geological formations belonging mainly to the Southern and Eastern Carpathians. The recent Lower Danube sediments in the Romanian sector (between Iron Gates area and the Danube Delta) are generally represented by clasts, muds and sands. In this work we pointed out the connection between the Lower Danube recent sediment and their main source based on the DZ geochronology tool, lithology and regional geomorphological factors. Analysing detrital zircons (DZ) ages from the riverine recent sediments a highly ranged spectrum of ages were identified. Most of the DZ exhibit three major groups of ages: i) Cambrian–Ordovician, related to back-arc basins and island arcs, linked to the Peri-Gondwana subduction (600–440 Ma); ii) Lower to Middle Carboniferous, associated with magmatic and metamorphic Variscan units (350–320 Ma), represented by dominant peaks in most analyzed samples; iii) Upper Cretaceous to Tertiary, younger than 100 Ma, possibly linked to the Southern Carpathian Upper Cretaceous Banatitic arc and to the Neogene volcanism of the Eastern Carpathians and Apuseni Mountains. Moreover, for the Lower Danube western tributaries the main sources of the DZ are the high-grade metamorphic rocks characteristic for the Danubian tectonic units of Dacia mega-unit. Some larger tributaries from the Lower Danube easternmost part show temporal disperse peaks on the DZ geochronology, feature probably reflecting successive processes of recycling. Notably, the most representative sources of DZ identified in the samples from easternmost Lower Danube tributaries are the Variscan metamorphites. In addition to the geochronology and geomorphology approach, for recognizing the source-to-sink complexity in the river catchments, multi-scenarios mixing are needed, to point out the transport ways and temporary or long-term preservation of sediments. For solving these issues, the detrital zircon mixing model allows the discovery of the undefined sources by the DZ fingerprint and the complex sedimentary provenance patterns.

Theme 13. Provenance of sediments – from source to sink

General Session

Oral presentation

The provenance of Upper Jurassic–Lower Cretaceous sediments of the Ceahlău–Severin Ocean: discriminating between passive margins source areas based on U-Pb detrital zircons ages

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We present new U/Pb LA-ICP-MS ages of detrital zircons extracted from Upper Jurassic–Lower Cretaceous (J_3–K_1) sedimentary rocks of the Ceahlău–Severin Suture of the Carpathians. The Ceahlău–Severin Ocean (CSO) opened during Middle Jurassic, separating the Dacia continental unit from the European Realm – a continental collage consisting of the Danubian unit, Moesian, East-European/Scythian platforms, and North Dobrogea Orogen. The magnitude of the extension and the amount of the oceanic crust produced are still debated. This work aims to evaluate how the different source areas contributed to the basin fill of CSO before the initiation of Barremian(?)–Aptian subduction of the European plate. The sampling localities cover a large area along the Romanian Carpathians. Until now, the J_3–K_1 deposits have been considered turbidites sourced exclusively from the Dacia unit and accumulated both on the continental and the new oceanic crust. Later on, during the subduction, the remnants of these formations were incorporated into the Cretaceous accretionary wedge. The age distribution of the seven newly analyzed samples ranges from 190 Ma to 3000 Ma. The dominant peaks are [290–340 Ma]; [440–470 Ma] and [540–650 Ma]. Considering that provinces delivering inherited zircons exceeding 1 Ga (e.g., the East-European Craton, distal Moesia basement in respect to CSO, and North Dobrogea) are minor contributors, the most probable sources are the opposite passive margins of the basin: on one side the Dacia unit, and on the other the Danubian unit, as well as proximal Moesia and the European Edge. The peak at ~460 Ma well represented in all samples corresponds to the metamorphosed Ordovician magmatic arcs of Dacia. The 540–650 Ma interval is well represented both in the Danubian/ East-European Edge, and Dacia unit, consisting of magmatic intrusions and Neoproterozoic peri-Gondwanian sedimentary deposits accreted to Baltica and metamorphosed during the Variscan orogeny. The 290–340 Ma magmatic intrusions are recognized in all surrounding areas of CSO, while the Varsican metamorphic zircons are specific for the Dacia unit. We interpret the Dacia unit as the main detrital source but do not exclude limited Danubian and European Edge contributions.

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General Session

Oral presentation

Two sides of the same coin? Benefits of comparative study of mudstones from early Mars and Earth

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Pondering mudstones on Earth & Mars is a study in contrasts. Not so much by way of the rocks, but by way of available tools for studying them. On Earth we rely on microfabric information from petrographic thin sections and SEM examination, whereas on Mars we are handicapped by the 10–20 microns per pixel resolution of close-up cameras carried on rovers. Particles smaller than coarse silt are unresolvable – one might feel inclined to abandon the inquiry altogether. Whereas on Earth, the most ancient mudstones (Archean) suffer from metamorphic/tectonic overprint, mm to sub-mm scale sedimentary features, e.g. lamination style (physical vs microbial), cross-lamination, scouring, evaporite crystals, etc. are equally or better observable in Martian vs terrestrial examples. As for microfabrics, Martian (not available) and Archean (not studied due to overprint) mudstones are at a similar disadvantage. However, technological advances (high-end SEM imaging combined with argon ion polishing) enable visualization of relict primary depositional and early diagenetic fabrics in Archean mudstones that inform about flocculation, bottom current activity (erosion, bedload transport of mud aggregates), benthic microbial mats, and recrystallization of evaporites from primary cumulates. Mars rovers collect mineral and geochemical data along with images as they traverse the terrain. Combined with geochemical and physical modeling these data point to commonalities (basaltic provenance, early diagenetic silicification & phyllosilicate formation) that provide helpful constraints on mudstone origins. For both early Earth and Mars, basalt–rainwater reactions result in high levels of dissolved silica in surface waters. Thus, abundant early diagenetic silica likely influenced the sedimentary behavior of surficial muds, like erosion in the form of soft mud aggregates that could redeposit under more energetic conditions than presumed for “regular” muds. The mudstones of one world pose intriguing questions and formative scenarios for the mudstones of the other. Although we have no choice but to approach Martian vs Archean mudstones from different data sets and investigative methods, they nonetheless share sedimentological and compositional traits that suggest an ancestry that transcends specific planetary origins.

Theme 13. Provenance of sediments – from source to sink

General Session

Oral presentation

The provenances and source-to-sink system evolution of Permian in NW Junggar Basin, China

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This study takes the Permian system in Junggar basin as an example to investigate the evolution of the provenance system based on the chronostratigraphy data, to analyze the stratigraphic and sedimentary pattern in the basin-scale geological sections. Finally the source-to-sink system evolution is discussed.

Statistical analysis of heavy mineral assemblage and detailed petrographic investigation of gravel sized clasts, combined with detrital zircon U–Pb geochronology, were conducted from sediments in different periods to understand the sediment provenance and unravel the source-to-sink processes in the studied region. The source-to-sink systems were traced and the evolution was comprehensively analyzed and its significance for tectonic evolution was discussed. The potential source area mainly exposes the Silurian, Devonian and Carboniferous igneous rocks and sedimentary rocks. Through heavy mineral assemblage and gravel composition analysis, it is clear that the parent rocks of the northwestern margin of Junggar Basin during the Permian are mainly intermediate–basic igneous rocks and intermediate–acid igneous rocks, mainly from the central West Junggar. There are a small amount of mixed remote sources in the northern Mahu Sag and Zhongguai Uplift, which come from the northern and southern parts of West Junggar respectively.

In Early Permian, Carboniferous of basin's periphery provided the majority sediments. Fan delta to lacustrine sedimentation with proximal provenance is dominant in most regions. High-quality hydrocarbon source rocks and delta front sandbodies constituted favorable reservoirs in Mahu and other depressions, In Middle Permian, the sedimentation center and subsidence center obviously migrated to the inner basin, and the early-formed faulted sags tended to be connected. The northwestern part of basin was still dominated by the fan deltas to lacustrine sedimentation system with proximal provenance. The large-scale hydrocarbon source rocks with high connectivity in the central basin, can form source–reservoir association with the delta front. In Late Permian, Large shallow lake allowed the development of regressive river-delta systems with distal provenance. They provided the reservoir for the basin-scale stratigraphic reservoirs.

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General Session

Poster presentation

The abundance of detrital muscovite in Paleocene–Eocene uraniferous strata sheds a new light on paleo-drainage system, Chu Sarisu Basin, southern Kazakhstan

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The Paleocene–Eocene sedimentary succession of the Chu–Sarisu Basin hosts world class uranium roll-front deposits. Despite its economic significance (~7% of global uranium production), the geological literature lacks documentation on sediment provenance. Recent core studies have revealed that Eocene strata contain an abundance of detrital muscovite flakes in high energy fluvial deposits, which have been interpreted as a product of high magnitude floods and rapid burial. A number of muscovite-rich terrains have been identified as potential source rocks on paleotectonic and paleogeographic maps: 1) Proterozoic Makbal Complex (Northern Tian-Shan); 2) Proterozoic Stepnyak volcanic arc; 3) Devonian Kazakh volcanic belt; and 4) Permian Kurama–Chatkal complex (Western Tian-Shan). Reconstruction of sediment transport routes shows that the northern and western Tian-Shan localities would require the longest (~300 km), E–W oriented, basin axial transport. The Devonian Kazakh volcanic belt is the closest (~170 km) and assumes a shorter N–S transport. Stepnyak volcanic would require the longest transport (~900 km) and passing through Paleozoic bedrock. The increased river discharge during and following PETM would allow for the generation of high magnitude floods even in low relief terrains such as in the Devonian Kazakh volcanic belt, as well as maintaining flood intensity from distant, higher relief sources such as Tian Shan and Stepnyak volcanic arc. Multiple sources are also possible. A comparison between potential source rocks and sink sediments will be undertaken using: i) petrography; ii) Ar^{39}/Ar^{40} radiometric dating of muscovite crystals; and iii) and U–Pb zircon dating. The results of this study will provide new information on sediment provenance and paleo-drainage, and novel insights on the regional distribution of reservoir facies, which is key for future uranium exploration activities. The present study is logistically and financially supported by KATCO JV LLP.

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General Session

Poster presentation

Head in the sand? An inter-laboratory comparison on detrital zircon age spectra reproducibility

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Detrital zircon (DZ) U-Pb geochronology is the gold standard in single-grain sedimentary provenance analysis (>58,000 results on Google Scholar) and is applied to tackle a wide array of geoscientific questions. In the past two decades, broader instrument availability and technological advances have led to increasing numbers of DZ analyses per study; thereby heralding the age of "big data" in detrital geochronology. To digest these larger datasets and to evaluate inter-sample relationships, many authors employ computational and statistical techniques that are sensitive to both the presence and the relative abundance of DZ age components. The results of such techniques often provide a framework for geological interpretations. At the same time, it is common practice to contextualize original data with literature data (e.g., to quantitatively compare different sedimentary units). However, DZ data originating from different laboratories are usually generated using distinct workflows. Importantly, some methodological steps during sample handling are known to potentially bias relative abundances of DZ age components (e.g., selection bias during handpicking). In turn, comparing data collected under variable circumstances can influence the results of computational or statistical techniques and hence, may result in flawed results and invalid interpretations. Yet, there is no community-wide study that has estimated the extent of sampling bias in natural samples originating from the methodological discrepancies. We propose such a study and are inviting contributors. Specifically, we are distributing heavy mineral and zircon concentrates to contributors, who are asked to conduct DZ geochronology using their established workflows. Consequently, contributors are expected to report results and methodological details for evaluation for anonymised collaborative publication. We aim to conduct a comprehensive assessment with a focus on understanding controls of intra-sample variability in the context of the various sample handling techniques. Ultimately, quantifying the degree of intra-sample variability introduced by different approaches, is expected to strengthen the robustness of future DZ studies (e.g., by providing empirical guidelines on handling data generated in different laboratories).

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General Session

Poster presentation

Košna conglomerates in the Velebit Mt., Croatia: particle composition, provenance and depositional environment

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In the vicinity of the 'Košna voda' spring in the Brušane area (Velebit Mt., Croatia), multicoloured Košna conglomerates attract attention due to their red matrix and clasts of various size and lithological composition (sandstones, limestones, chert and quartz). The conglomerates are poorly sorted, but locally show normal grading, imbricated clasts and stratified matrix, suggesting tractive particle transport. Sandstone clasts are classified as: lithic arenites, subarkoses and arkoses, with fragments of fusulinid foraminifera. Limestone clasts are mostly shallow-marine wackestones to packstones of Late Carboniferous/Early Permian age, with foraminifers, ostracods, echinoid and bryozoan fragments. *Microcodium* and calcispherae are also present in clasts, suggesting different sources and resedimentation. Based on field observations and conducted petrographic, ore microscopy and X-ray diffraction analyses, the Košna conglomerates are defined as Early Permian polymict clast-supported and matrix-supported conglomerates derived from the uplifted Hercynian Mountains and deposited and reworked in a shallow marine environment. Due to their structural and textural features, they are comparable with Late Paleozoic conglomerates from other areas in the Dinarides, Eastern and Southern Alps.

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General Session

Poster presentation

The provenance of rutile and zircon from the Miocene Zr–Ti placer deposits, Ukraine

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In our research we intended to define the provenance of zircon and rutile from four placer Ti–Zr deposits in Ukraine (Krasnokutsk, Tarasivka, Samotkan and Vovchansk). To do so, a series of chemical and U-Pb isotope analyses of rutile and zircon was conducted (LA-ICP-MS of rutile from the Krasnokutsk, Tarasivka and Samotkan deposits, EDS and WDS of rutile and zircon from the Krasnokutsk, Tarasivka and Samotkan deposits). These deposits were formed in Miocene, but at different tectonic settings. The Krasnokutsk deposit is located on the slope of the Dnipro–Donetsk basin, while Tarasivka, Samotkan and Vovchansk are placed on the slopes of the Ukrainian Shield. Variations of ZrO_2/HfO_2 with HfO_2 in zircons from the Samotkan, Tarasivka, and Vovchansk Ti–Zr deposits demonstrate the low content of Hf in placer zircons, and also allows us to assume that zircons from the Tarasivka and Vovchansk deposits, and some zircons groups from the Samotkan deposit were mainly derived from crystalline rocks of intermediate and basic composition, while the rest of zircons from the Samotkan deposit were derived from the felsic rocks. Zircons from deposits reveal similar age patterns. The main peaks occur at ca. 2800–2700, 1900–1800, 1650–1600, 1150–1050, and 550–500 Ma. The first two populations could have been derived from local sources in the Ukrainian Shield, whereas younger populations require more distal sources, or represent redeposited material from the Neoproterozoic sediments. The youngest zircons were dated at 265 Ma in the Samotkan placer, 456 Ma in the Tarasivka placer, and 148 Ma in the Vovchansk deposit. Most of the rutiles from the Samotkan, Tarasivka, and Krasnokutsk deposits have a U–Pb age in the range 2100 to 1800 Ma, indicating their derivation from the local sources in the Ukrainian Shield. A large number of rutiles from the Tarasivka deposit, and a few from the Samotkan and Krasnokutsk deposits have U–Pb ages between 550 and 400 Ma; their source remains unknown. The majority of rutiles from the Samotkan, Krasnokutsk, and Vovchansk deposits were formed at a temperature over 750 °C, while most of rutiles from the Tarasivka deposit were formed at a temperature of 500–750 °C. Relatively few rutile grains from all four deposits were formed at a temperature less than 500 °C.

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General Session

Poster presentation

Sediment origin of the Black Flysch and the Ceahlău thrust sheets from the Eastern Carpathians – tectonic implications

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In the northern part of the Eastern Carpathians, the Maramureş area exposes a series of tectonic units comprising remnants of the Mesozoic Ceahlău–Severin Ocean. The Black Flysch unit contains a Middle(?)–Upper Jurassic mafic complex overlayed by Late Jurassic–Early Cretaceous (J_3–K_1) sediments including deep-water carbonates and siliciclastic deposits. The mafic complex contains alkaline basalts of intraplate affinity, which differ from the oceanic E-MORB-like basaltic blocks incorporated in the J_3–K_1 sediments of the Ceahlău unit towards the east, thus suggesting a different tectonic setting. If so, were the sediments of the Black Flysch and Ceahlău units deposited in the same basin or in two distinct basins? A more detailed geochemical evaluation of the basalts is undoubtedly required to answer the question, but a meaningful step forward can be made by the quantitative provenance analysis of the syn-extensional siliciclastic J_3–K_1 sediments in both units. The detrital zircons U-Pb age distribution spectra obtained for two samples representing the two units are similar, within the 180–3000 Ma range. The peaks of the distribution have values or ranges at ~460; 580–620; ~320; 180–200 and 950–1100 Ma. In the Black Flysch unit, Ordovician ages (~460 Ma) specific to the basement of the Bucovinian nappes dominate, while in the Ceahlău nappe, the Late Neoproterozoic peak of ~600 Ma is more representative and has a counterpart both in sediments of the Eastern European margin and in paragneiss of the Bucovinic domain. The small percentage of inherited ages that exceed 1 Ga makes the East-European Craton an insignificant source area. In conclusion, the Bucovinian units must have been the main source for both sedimentary basins, Ceahlău and Black Flysch. The differences in age distribution are likely given by the compositional heterogeneity of the source area. The presence of a Bucovinian-type ridge separating the intra-continental and oceanic rift basins cannot be excluded. The Early Jurassic ages of 180–200 Ma could suggest magmatism associated with the beginning of extension, but further detailed studies are needed to verify this hypothesis.

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Theme 13. Provenance of sediments – from source to sink

General Session

Poster presentation

Plastic pellets as sedimentary components on a coastal dune system

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Plastic pellets are component of a size < 5 mm deposited into the beaches as result of anthropogenic activity and/or a spread in marine environments. These pellets are involved in the sedimentation processes that act on the coastal zone becoming part of the stratigraphic record. In this study we documented a large quantitative of plastic pellets into the Lascari–Campofelice beach (north Sicily coast) after a storm event. The same plastic pellets were found at the base of the coastal dune system at a depth of 5 cm, suggesting their involvement in the coastal processes. The physico-chemical characterization allowed us to identify the plastic pellets as polypropylene. A photodegradation of the pellets was observed thanks to NMR, DSC and FT-IR analysis. Moreover, SEM micrographs showed surface degradation with salt deposition, indicating their permanence in the marine environment.

Theme 13. Provenance of sediments – from source to sink

General Session

Poster presentation

Sediments buffering system in the Thar sand dunes for provenance studies

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Thar Desert straddles between eastern Pakistan (Punjab and Sindh) and western India (Rajasthan state) with an extension of 250,000 km^2 and it is considered to be active since middle Holocene. Desert dunes are composed of recycled sediments from the western and eastern Himalayan orogen supplied by the Indus River from the west and by its Punjabi tributaries (Chenab, Jhelum, Beas, Ravi and Sutlej) from the north-east. This unique provenance setting allows the study of the sediments buffering systems to understand critically how sediments are transferred from source to sink, involving fluvial and aeolian interaction with different environmental signals. One of the climatic forcing factors is the Summer Monsoon System (SMS), which is responsible for the relative interplay between the aeolian system and the strength of the river network to control the sediments deposition and erosion at regional scale. However, in the Thar Desert, there is still an important challenge to mark the climatic change with respect to the provenance studies and tectonics. To unravel sediments interactions between the Himalayas and Thar Desert for the provenance studies, we have applied a multi-technique provenance study approach, including bulk petrography, heavy mineral analysis and detrital zircon dating to correctly discriminate sediment sources and to describe the sediment routing system. Thar Desert has quite homogenous litho-feldspatho-quartoze to partly feldspatho-litho-quartzose composition (sedimentary to low grade metamorphic lithics) with a heavy minerals rich suite of amphibole, epidote and garnet, pointing towards an orogenic setting provenance. Detrital zircon age distribution is similar to the Indus River, sourcing in Ladakh, Kohistan and Nanga Parbat domains, but with a major and consistent Neoproterozoic age population sourcing from the Punjabi tributaries draining the Greater and Tethys Himalaya. This study is useful to prove an evolution in the Holocene for the Thar Desert, which plays a buffering role in the sediments transfer from the Himalaya, with relative contribution of rivers and different source areas.

Theme 13. Provenance of sediments – from source to sink

General Session

Poster presentation

Provenance assessment of the Triassic Chang 6 Formation in the west Yanchi area, Ordos Basin, China

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During the Triassic period, Ordos Basin was surrounded by many archicontinents, including Yinshan orogenic belt to the north, the Alashan in the northwest, the Qilian–Qinling orogenic belt in the south, and the Longxi in the southwest. These archicontinents were the main provenances of clastic sediments supply in the Ordos Basin. In this research, the sources of the Triassic Chang 6 Formation from the western Yanchi area of Jiyuan Oilfield are deeply studied using paleo-flow data, microfacies analysis, cathodoluminescence (CL), electrical micro-imager logging (EMI), heavy mineral distribution, rare earth elements (REE), etc. The outcrops of the paleo-river channel in the Rujigou and Shigouyi area (located in the northwest of the study area) show water flow was primarily in the northwest–southeast direction (103°∠22°~134°∠26°). The sedimentary facies analysis exhibits the mudstone microfacies extend along northwest–southeast, consistent with the source direction. EMI data of 19 wells indicates the sedimentary bedding is steeply sloped, dipping 105°~165° SE (i.e., paleowater flow direction). Moreover, CL shows quartz is primarily brownish-yellow and blue-violet. It indicates the source of medium to high-grade metamorphic rocks, derived from the Alashan archicontinent in the northwest to the west Yanchi area. The distribution of heavy minerals depicts both zircon content and ZTR index increases from northwest to southeast. Furthermore, REE data shows much better similarities between the study area and northwest provenance than the other sources. Based on these evidences, it is clear that the sediments supply of the Triassic Chang 6 Formation from west Yanchi area in Jiyuan Oilfield came from the archicontinent of Alashan located in the northwest margin of Ordos Basin.

Theme 14. Tectonics and sedimentation

Special Session 14.1. Intramountain basins – recorders of tectonics, climate, and biota interactions

Oral presentation

Tectonic control on the deposition of the travertine in Levač Basin (Serbia): insight on miocene extensional phases in the Dinarides–southernmost Carpathians junction

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Travertines are terrestrial carbonates precipitated in the vicinity of, often fault-controlled, thermal springs in extensional and transtensional sedimentary basins. In these settings, faults and fissures act as circulation and mixing paths of carbonate-enriched thermogenic and meteoric fluids, from which travertines precipitate at the surface. Therefore, travertine successions provide key information about the interplay between faulting, deposition, climate and fluid flow. This study investigates the travertine succession in the Miocene Levač Basin, the peripheral basin of the Morava corridor located at the interference zone between the Dinarides and the southernmost Carpathians. We analysed the sedimentology, composition, U-Pb age (LA-ICP-MS) and relation to the faulting of the travertines to reconstruct the spatiotemporal evolution of the feeding hydrothermal system. We aim to use the high-resolution record of the travertine to improve controls on sedimentation and faulting in Levač Basin and finally to elucidate the mechanisms controlling the Morava Corridor evolution during the Miocene. We distinguished four facies associations, travertine slope, ridge, flat, and travertine flat under the fluvial influence. Travertine deposition is controlled by basin-forming NW–SW – and NE–SE normal fault arrays, making the link with regional tectonics. Stable oxygen and carbon analysis yield $\delta^{13}C$ values shifting from positive to negative (with $\delta^{18}O$ being negative) towards the stratigraphically younger and more distal deposits, which suggests a progressive dilution of the endogenic fluids by mixing with meteoric water. Finally, the new U-Pb age of ~14 Ma obtained for the travertine deposits in the Levač basin, implies that the Middle Miocene extensional phase known from other intermountain basins in the Dinarides reached as far east as the Morava Corridor.

Theme 14. Tectonics and sedimentation

Special Session 14.1. Intramountain basins – recorders of tectonics, climate, and biota interactions

Oral presentation

Terrestrial carbon cycles unravelling longer-term patterns of ecosystem and climate following the end-Cretaceous extinction

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Mass-extinction with instantaneous and short-term effects on extreme climate and deteriorated environment across the Cretaceous/Paleogene boundary (K/PgB) has been verified by an array of evidence, however, a longer-term (~100–1000 Kyr) post-K/PgB variation remain poorly understood, particularly due to the scarcity of terrestrial records. This study presents carbon isotope ($\delta^{13}C$) analyses of pedogenic carbonates in the Nanxiong Basin, South China to reconstruct carbon cycles and atmospheric CO_2 concentrations (pCO_2) spanning 70.0–62.0 Ma. Results show that $\delta^{13}C$ ranges from −12.41‰ to −4.98‰ (mean −8.95‰, gap Δ≈6.5‰) and pCO_2 changes between 250 ppmV and 2500 ppmV (mean 960 ppmV, gap Δ≈ 2000 ppmV). Combined with data from Songliao Basin (China) and Tornillo Basin (USA), $\delta^{13}C$ displays a post-K/PgB (66.0–64.5 Ma) vibration that is correlative to the surface ocean but mirroring the bottom ocean. The vibration exhibits a pattern of collapse and smooth towards rebound, constituting a process of ~400 Kyr (millennia) deterioration, ~300 Kyr stabilization and ~800 Kyr recovery for the longer-term ecosystem and environment. A similar pattern is observed for pCO_2, correlating sea surface temperature (SST) but contrasting bottom water temperature (BWT). With discrepancies of proxy variations, it is proposed that ecosystems and environments in terrestrial and surface ocean had experienced a more unstable, difficult and erratic recovery process and were much more sensitive to climatic changes than in deep ocean for ~1.5 million years in the aftermath of end-Cretaceous mass extinction, which may have been relatively buffered due to the time lag for such major temperature changes to infiltrate into the deep sea and likely indicate the recovery capability of terrestrial ecosystems could be much more powerful than we expect. In addition, the decoupling of proxy variations from expected effects implies Deccan volcanism and Chicxulub impact may not have played a key role in the longer-term CO_2 perturbation and environmental change following the K/PgB.

Theme 14. Tectonics and sedimentation

Special Session 14.1. Intramountain basins – recorders of tectonics, climate, and biota interactions

Keynote lecture

Deep drilling in ancient Lake Ohrid reveals 1.4 Myr of geological and evolutionary history

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Lake Ohrid on the Balkan Peninsula is the oldest and most biodiverse freshwater lake in Europe. To unravel its geological, climatic and evolutionary history, a continuous sedimentary sequence was recovered from the lake in 2013 as part of the International Continental Scientific Drilling Program (ICDP). The record comprises lacustrine sediments deposited since the lake's formation 1.36 Myr ago. They cover both the environmentally dynamic shallow-water and the more stable deep-water phases of the lake. Processing of the cores revealed uninterrupted time series of environmental and climatic indicators as well as a unique fossil record. Complementary biostratigraphic, seismic and molecular-clock information obtained as part of the deep drilling campaign indicate that sediment infill of the basin started about 2.0 Myr ago. The results emphasize the importance of the interplay between environmental/climate change, ecosystem stability and ecological opportunities for biological evolution. In particular, they show that: i) Lake Ohrid evolved de novo in the Ohrid Graben from karstic springs or rivers, ii) the main radiations of endemic species in the Ohrid Basin were triggered by major geological events such as basin formation, lake formation and onset of deep water conditions, iii) speciation and extinction rates almost simultaneously decreased in the environmentally dynamic phase after ecosystem formation and stabilized after deep-water conditions established in Lake Ohrid, iv) the temporal evolutionary dynamics in Lake Ohrid are not consistent with the predictions of the General Dynamic Model of Island Biogeography. The exceptional sediment record obtained for Lake Ohrid provides a detailed picture of the geodynamic evolution of an intra-mountain basin and contributes to answering one of the major questions in science "What drives species diversity?".

Theme 14. Tectonics and sedimentation

Special Session 14.1. Intramountain basins – recorders of tectonics, climate, and biota interactions

Poster presentation

Orbitally induced climate signal in the Lower Cretaceous synrift lacustrine sediments of the Enciso Group (eastern Cameros Basin, N Spain)

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The Enciso Group (eastern Cameros rift basin) is represented by a thick succession made up of sandstones, silstones, marlstones and limestones organized into sedimentary cycles of different rank. Magnetic susceptibility was measured every 50 cm in a 1,371 m-thick stratigraphic section in the vicinity of Navalsaz (La Rioja, Spain). Samples were taken every meter to measure the carbonate content and colour parameters (CIE L* a* b*) in the laboratory. Continuous quantitative time series (depth domain) were constructed from values of magnetic susceptibility and total carbonate content, as well as from luminosity (L*), red/green (a*) and yellow/blue (b*) coordinates. Multi-Taper (MTM) spectral analyses show similar results for the different time series, and reveal a dominant 80–180 m range periodicity together with other higher frequency periodicities. The dominant periodicity has been referred to the large eccentricity cycle (405 kyr), which has been recorded as cycles ranging from 54 to > 150 m-thick. Lower periodicity cycles (25–48 m, 10–15 m, and 3–7 m) have been referred to Milankovitch frequencies of short eccentricity, obliquity and precession. The occurrence of numerous peaks with close periodicities has been interpreted as variations in the rate of sediment accumulation due to synsedimentary tectonic forcing. The Acycle-COCO and eCOCO tools have allowed to obtaining sedimentation rates with two main maxima (9–14 and 27–29 cm /kyr) appearing along the sedimentary succession. Nineteen complete cycles and other two incomplete ones have been obtained by applying a Gaussian filter smoothing of the magnetic susceptibility series centred on the large eccentricity cycle periodicity. A time span of ca. 7.8 Ma for the unit has been obtained, which is larger than the duration proposed by previous works.

Theme 14. Tectonics and sedimentation

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Poster presentation

Middle Miocene continental paleoenvironmental records from the Dinaride Lake System

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The Dinaride orogenic belt connects the European Alps with the Albanides–Hellenides fold-and-thrust belts. During the Miocene, the Dinarides hosted several lakes in intramontane basins, which are collectively called the Dinaride Lake System (DLS). The DLS reached its greatest extent during a period of global warmth, the Miocene Climatic Optimum (MCO; ca. 16.9–14.7 Ma). A subsequent shift to much colder climatic conditions during the Middle Miocene Climate Transition (MMCT; ca. 14.7–13.8 Ma) led to the establishment of permanent Antarctic ice masses. Compared to marine paleoclimate archives, continental paleoclimate records of the MCO and MMCT are scarce. The sedimentary record of the DLS provides an excellent opportunity to study continental climate dynamics during the MCO and MMCT in southeastern Europe. We, therefore, sampled seven well-dated basins in Croatia and Bosnia and Herzegovina (Pag, Sinj, Bugojno, Kupres, Livno–Tomislavgrad, Gacko, and Sarajevo–Zenica) for stable carbon and oxygen isotope-based paleoenvironmental reconstructions that cover the time interval from 18 to 13 Ma. Preliminary stable isotopic data reveal a positive covariance between $\delta^{13}C$ and $\delta^{18}O$ values for most basins, indicating the lakes were hydrologically closed. Initial data from two time-equivalent sections that cover the onset of the MCO show ca. 4.1‰ lower $\delta^{18}O$ and ca. 5.3‰ lower $\delta^{13}C$ values for the present-day coastal Pag section than for the Livno–Tomislavgrad basin, which is presently located ca. 50 km inland from the Mediterranean Sea at ca. 700 m elevation. Therefore, the more internally located Livno–Tomislavgrad basin seems to have experienced more evaporative conditions. Collectively, existing palynological data, sedimentological observations, and our new stable isotope data will shed light on the rise and fall of the MCO and the impact of the subsequent MMCT in southeastern Europe. Structural mapping of selected basins will be performed to elucidate the role of tectonics on the development of the investigated intramontane basins.

Theme 14. Tectonics and sedimentation

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Poster presentation

Climate, tectonics and microbial influence in sedimentation in a Cretaceous carbonate Mg-rich shallow lacustrine system (Aguilon sub-basin, Iberian Basin)

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The Villanueva de Huerva Formation (Valanginian to middle Hauterivian in age) is a syn-rift shallow lacustrine stratigraphical unit (ca. 200 m-thick) in the endorheic Aguilón sub-basin (Central Iberian Range, Spain). A cyclical interval (50 m-thick) in its middle–upper part comprises climate-driven, deepening–shallowing-upward sedimentary cycles modulated by tectonics. Lacustrine facies include carbonate sandstones, marls, dolostones (laminated, massive and bioturbated/brecciated) and rare limestones. Facies, along with mineralogy and carbonate isotope composition, evince dry environmental general conditions during sedimentation, punctuated by more humid stages with freshwater incomings to the lake. Integrated analysis of changes in cycle thickness and sedimentary facies allows proposing several scenarios in which climate and tectonics played distinct roles in controlling the accommodation space and water/sediment supply to the lake. Field emission scanning microscope observations show that magnesite and Fe-oxides are also present and that Mg-bearing carbonates are commonly associated with micro-organisms, providing strong evidence about they played a main role in precipitation, as reported in other shallow brackish and saline lakes. It is proposed that dolomite precipitated with sulphate-reducing bacteria mediation in $\delta^{18}O$ evolved waters with relatively light ^{12}C organic contribution to the dissolved inorganic carbon, and that Fe-oxides probably derived from oxidation of previous FeS_2 in the lake bottom sediments. Carbonate $\delta^{18}O$ and $\delta^{13}C$ values point to a closed hydrological lacustrine system in which dolomite precipitated under brackish conditions and sulphate salts grew during more evaporative stages; salt dissolution and dedolomitization processes occurred in relation to meteoric water influxes during wetter episodes. Taking into account the paleogeographical configuration, waters acquired the required cations (Mg^{2+}) for dolomite and magnesite genesis by washing rich-Mg carbonate units in the subsoil and migrated upwards through synsedimentary normal faults that acted as preferential ascension flow paths towards the lacustrine system.

Theme 14. Tectonics and sedimentation

Special Session 14.1. Intramountain basins – recorders of tectonics, climate, and biota interactions

Poster presentation

Shallow to deep marine and continental deposition in the Haţeg intramountain basin (SW Romania): influence of the tectonics on the biotic changes

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The Haţeg intramountain basin is situated within the Southern Carpathians (SW Romania), being shaped at the Cretaceous end, in response to the Laramian collision of the Getic and Danubian tectonic units. Within the Middle Jurassic up to the Early Cretaceous (Aptian) times, the area was part of the Getic Carbonate Platform. Since the Aptian, following the mid-Cretaceous ("Austrian") tectonic phase, the region was uplifted for a short interval, event accompanied by a regressive phase. During the exhumation period, which lasted throughout the Albian, the weathering products were accumulated in the karstic depressions formed on the top of the Urgonian limestones, generating bauxite deposits. The uppermost Albian is characterized by the presence of molasse deposits with coal lenses. The marine conditions were resumed at the beginning of the Late Cretaceous, and lasted from the Cenomanian up to the late Campanian. Significant fluctuations between a marine shallow water paleosetting and a deep marine one is to remarked between the NW and SE regions of the Haţeg Basin. In the NW part, during the Cenomanian–Turonian interval, red and green marlstones, overlie by Coniacian–lower Maastrichtian turbidites occur. In SE Haţeg, Cenomanian–Turonian gastropods and rudist-bearing limestones, sandstones and microconglomerates cropped out, followed by Santonian–lower Campanian marine variegated marlstones and claystones, and Campanian–lowermost Maastrichtian turbidites. The marine sedimentation ends in the SE part with a lower Maastrichtian shallow deposition, i.e., sandstones with rudistes. During the early Maastrichtian collapse of the orogen, a strong subsidence took place in the Haţeg area, reflected by the several thousand m-thick terrestrial molasse deposits accumulated in the basin, followed by the Paleogene uplift of the basin and the formation of a positive relief at the collision zone. In the whole region continental deposits with numerous fossils, including Maastrichtian dinosaur ones (a remarkable endemic faunas) are widespread. The significant changes in the sedimentation pointed out in the Haţeg Basin mirror the interaction between tectonics (i.e., the mid-Cretaceous and Laramian phases) and the shift in the biotic composition, from shallow to deep marine and finally continental ones.

Theme 14. Tectonics and sedimentation

Special Session 14.1. Intramountain basins – recorders of tectonics, climate, and biota interactions

Poster presentation

Late Quaternary tectono-climatic coupled geomorphological and sedimentary feedback in Trans-Himalayan Spiti River Basin, Himachal Pradesh, India

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The Spiti river basin, sandwiched between ISM (Indian Summer Monsoon) influenced Main Central Thrust to the south, and WD (Western Disturbances) influenced Karakoram fault in the north, offers a unique avenue to study the terrestrial Quaternary depositional settings in the Trans-Himalaya. The role of Quaternary climatic transitions and resultant varying intensity of ISM and WD, complemented with neo-tectonic activity associated with the local and regional faults, controls the landscape evolution of the Spiti river basin. Our study focuses on the spatio-temporal Quaternary landscape evolution of Spiti based on litho-facies analysis of Quaternary deposits, supplemented with their clast macro-fabric, orientation studies, and available chronologies.

The upper part of the Spiti, encompassing glacial, glacio-fluvial, and fluvial sediments, shows a braided stream pattern with high valley wall sediment influx. The lower part of the Spiti beyond Mane follows a meandering pattern in an incision-dominated environment. In addition to this, there are also lacustrine deposits present at multiple locations, such as Kioto, Atargu, Mane, and Chango. These are formed by landslides, debris flows, and glacial ingressions blocking the trunk channel in the past at constrained channel width locations. These constrained channel width points result from topographic perturbations caused by the local fault systems (*Kaurik–Chango, Mane, Lingti, Kioto faults*) and regional tectonic forcings. The presence of soft sedimentary deformations/seismites(?) in the Quaternary deposits and morphometric characters of the Spiti river basin supports the evidence of neo-tectonic perturbations complementing the aggradation and incisional phases across the basin. It proves the competing role of climate and tectonics controlling the landscape evolution of the Spiti river basin. Our study suggests the headward development of the Spiti trunk channel across the Late Quaternary, in the East–West direction, complemented by the local fault systems and overall regional SW–NE divide migration trend caused due to coupled effect of ISM and regional Himalayan thrust propagations.

Theme 14. Tectonics and sedimentation

Special Session 14.1. Intramountain basins – recorders of tectonics, climate, and biota interactions

Poster presentation

Paleowind directions recording Late Cretaceous monsoon in East Asia

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Modern monsoon systems in Asia started around the cooling late Eocene–Miocene (36–20 Ma), but it is still unclear if there had been a monsoon system in East Asia during the greenhouse Cretaceous. This paper provides positive evidence on the question. We have studied a bundle of early Late Cretaceous sandstones in South China, in order to examine the sandstone property and to reconstruct paleowind directions. The Results have showed that sandstones are commonly reddish orange in color with prominent large-scale and high-angle cross-beddings and laminal sets which are often massive (>2 m thick, up to 15–20 m). The result have also exhibited evidence that sandy grains range 65–221 μm (σ 0.37–0.81) in size and are mainly sub-rounded and sub-angular with some eolian surface textures, together demonstrating the late Cretaceous eolian records in South China. From measurements of 2400 laminal occurrences of 300 large cross-bedding sets at 90 observations in 12 basins, the reconstructed paleowind directions show ~5°–200° from which two main paleowind sets NE ~53° and SE 123° are prevailed with a minor NNW set. Combined with previous works (1500 laminal occurrences), the results have showed similar styles of paleowind directions. The main paleowind direction sets are not compatible with the westerlies and northeast trade winds of the Neogene to modern planetary system. We interpreted the monsoon imprints, in which the southeastward paleowind direction set suggests the winter monsoon blowing from northwest, and the northeastward direction one the summer monsoon blowing from southwest along the lowland between the Jiangnan Orogen and leeward side of Coastal Range. The summer monsoon from SE Paleo-Pacific Ocean might not have overpassed the Coastal Mountain and imprinted eolian directions in sandstones, but may have turned around the southern corner of the Coastal Mountain in East Asia and transferred as the NE direction summer monsoon in the lowland between the Jiangnan Orogen and leeward side of the Costal Mountain.

Theme 14. Tectonics and sedimentation

General Session

Oral presentation

Structural and sedimentary characterisation of Rotliegend units at the basement/sedimentary unconformity: implications for heat storage development in the Upper Rhine Graben

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Heat storage is a promising technology because it can provide a reliable heat source and help increase energy system efficiency and reduce greenhouse gas emissions. Aquifer thermal energy storage (ATES) and borehole thermal energy storage (BTES) systems work by circulating fluids with seasonal or shorter periodicity (in closed or open loop systems).

This process allows excess heat and-or cold to be stored in the subsurface for later retrieval and use in the surface heating network. When reaching medium depths (above 500 m), such storage systems can allow high-temperature gradients (above 30°C/km), thus producing high-temperature ranges and high-grade systems. However, they require drilling medium–deep boreholes into often complex, sometimes fractured, heterogeneous lithologies. Therefore, the geological uncertainties must be integrated from the early planning stage.

In the area of investigation, e.g. the north-eastern border of the Upper Rhine Graben, the near-surface basement is covered by Rotliegend Permian units. For BTES systems, permeable sedimentary aquifers in the near-surface and a potential connection with the crystalline structural system may affect the storage site economic and environmental feasibility, and thus must be considered. For ATES systems, the critical factor is to characterise which levels and sub-units present the most favourable potential with appropriate hydraulic behaviour for the Rotliegend units.

For these two applications, structural and sedimentary characterisation of the Rotliegend sedimentary and volcanic units assessed with a multi-scale approach will be presented. and the assessment is based on different datasets from fieldwork, borehole geophysics, petrographic analyses of cutting material, and subregional models gained from the PotAMMO and the SKEWS (Seasonal Crystalline Borehole Thermal Energy Storage) projects (project administrator Jülich, research project SKEWS, funding code 03EE4030A; research project PotAMMO, funding code 03G0913B). As a perspective, the upscale and applicability of these models, approaches, and integration will be discussed for both BTES and ATES systems in the framework of the Horizon Europe PUSH-IT project at the European scale.

Theme 14. Tectonics and sedimentation

General Session

Oral presentation

Prism-top or retro-prism forearc basin? Evaluating tectonic models for Danian (Paleocene) strata of the southwest Canadian Cordillera

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Forearc basins are divided into prism-top basins, which overlie the accretionary prism, and retro-prism basins, which overlie the upper plate. Research has largely focused on prism-top basins leading to a wealth of information on their evolution and classification; hence, most forearc basins are interpreted by default as prism-top basins. Here, we integrate stratigraphic and detrital zircon data from Danian (Paleocene) strata of the Georgia Basin and affiliated Suquash outlier in the southwestern Canadian Cordillera (Vancouver Island, Canada), and evaluate tectonic models in which these basins are presented as either prism-top or retro-prism forearc basins. Our data shows that in Danian time, the Suquash outlier experienced low total subsidence and was situated by an orogenic arc. In contrast, the Georgia Basin experienced high total subsidence and was situated by a topographically low arc. We use these results to evaluate whether these basins developed in a prism-top or retro-prism setting. If the Suquash outlier and Georgia Basin are interpreted as prism-tops then differences between these basins reflect differences in the evolution of the accretionary prism. If the Suquash outlier and Georgia Basin are interpreted as retro-prisms then the same differences reflect variations in the geometry of the descending slab. We prefer the retro-prism interpretation because it honours both the position of the basins over the upper plate and differences in subsidence and arc-topography between the basins, whereas the prism-top interpretation only accounts for differences in subsidence. Accepting the retro-prism model implies the existence of a double forearc basin configuration on the southwestern margin of the Canadian Cordillera during Danian time, wherein prism-top basins developed over the accretionary prism and retro-prism basins (i.e., Georgia Basin and Suquash outlier) were inland of this.

Theme 14. Tectonics and sedimentation

General Session

Oral presentation

Tectonic control on the formation of Middle Miocene Leitha build-ups in the Pannonian Basin

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In the last three decades, the extensive hydrocarbon exploration in the Pannonian Basin (PB) resulted in an immense amount of data on Middle Miocene bioclastic mixed-carbonate reservoirs assigned to Leitha Limestone. In addition to lithological variability, they occur in various stratigraphic successions and structural positions. The objective of this study is to reconstruct the Middle Miocene basin geometries, and to define the different tectonic situations influencing the shallow marine limestone development. Several industry grade 3D seismic cubes (more than 1000 km^2) and calibrated well data from the SW part of the PB were used to constrain the models. In the Central Paratethys the Leitha Limestone development is usually connected to the Middle Miocene climatic optimum and the relative sea-level rise, caused partly by eustatic signals and the overall subsidence of the PB. The sea level rise results in the flooding of the previously subaerally exposed areas, thus the shrinking of the hinterland and the reduction of the siliciclastic sediment input, which is favorable for limestone deposition. The deposition of carbonate build-ups is determined by the basin morphology which is controlled by tectonic processes. In the study area, the Middle Miocene rifting was shortly followed by the inversion of the basin, characterized by N–S compression. This is indicated by numerous new reverse faults, reactivation of older structures, and development of a complex, folded terrain upon which isolated shallow water conditions lead to the accumulation of carbonate build-ups. In this study, we managed to identify several different, partly structurally controlled paleogeomorphological settings, where Leitha Limestone developed. These build-ups can form at the crests or the flanks of the inverted anticlines, depending on the offset of the faults. Similarly, volcanic bodies, inherited basement highs or differentially eroded surfaces might also create favorable positions for carbonate deposition. These are profoundly different from the Middle Miocene shallow-water limestones in the Carpathian Foredeep Basin, where enormous, connected build-ups developed. Within the PB, small, segmented carbonate build-ups, can be mapped, which are often viable hydrocarbon reservoirs.

Theme 14. Tectonics and sedimentation

General Session

Oral presentation

Late Cretaceous inversion tectonics as a driver for the development of the Szozdy Deltaic System in the heart of the Polish Basin

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The Polish Basin, and its axial most subsiding part – the Mid-Polish Trough formed the eastern part of the Permian–Mesozoic system of epicontinental basins of western and central Europe. It undergone uplift during the Late Cretaceous, which in consequence resulted in the inversion of its axial part (i.e. the Mid-Polish Trough) and transformation into the Mid-Polish Anticlinorium. Recent data, however, suggest that southeastern Poland was already a landmass (Łysogóry–Dobrogea Land) by the Coniacian and Santonian – and certainly in the Campanian and Maastrichtian – rather than forming the deepest part of the Polish Basin. The Campanian, shallow marginal marine, cyclic, marly to sandy deposits of the Roztocze Hills are interpreted to be of deltaic origin (Szozdy Delta System; Remin et al., 2022). The proposed facies and bathymetric models imply the presence of a landmass in the place where, in prior frameworks, the deepest and most rapidly subsiding part of the Polish Basin (i.e., the Mid-Polish Trough) was located. The sequence, as a whole, accumulated via the repeated progradation and abandonment of deltaic complexes on a delta front platform setting, with the primary transport direction originating from the axis of the inverting Mid-Polish Trough (thus from the subsurface San Anticlinorium) towards the north-east. This interpretation is supported by a suite of sedimentological, palynofacies and heavy mineral data. The development of the Szozdy delta system is framed in the context of the dynamic tectonic processes operating contemporaneously in south-east Poland: that is, tectonic inversion (uplift) on the one hand and the generation of new accommodation space via enhanced subsidence on the other. This discovery sheds new light on our understanding of Late Cretaceous facies distribution, bathymetry, palaeogeography and potentially might suggest a different burial history than assumed so far.

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Reference

Remin, Z., Cyglicki, M. and Niechwedowicz, M. 2022. Deep vs. shallow–two contrasting theories? A tectonically activated Late Cretaceous deltaic system in the axial part of the Mid-Polish Trough: a case study from southeast Poland. Solid Earth, 13(3), 681–703.

Theme 14. Tectonics and sedimentation

General Session

Oral presentation

Tectonostratigraphic control on the development of Mississippian carbonate platforms in the southern Irish Sea Basin

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Mississippian-aged carbonate strata provide a potential resource for geothermal projects onshore and offshore UK. However, poor seismic data quality onshore limits our ability to image the platforms and their margins. The purpose of this study is to identify Mississippian-aged carbonate platforms in the southern part of the Irish Sea Basin, western UK, using 3D seismic data and some geological field data from the North Wales Platform. These data are used to assess the importance of tectonic structure on carbonate platform architecture, growth, and thickness, as well as the position and trajectory of the carbonate platform margin through time. The interpretation of 3D seismic data produces three important surfaces: Upper carbonate (equivalent to upper Visean), intra Visean, and base carbonate (equivalent to base Tournasian). Back-arc extension began during the Devonian–Early Carboniferous with NE–SW extension creating the geometry of fault growth and linkage to produce a horst–graben structure that accommodated carbonate platform growth. The reactivation of faults by E–W extension in the Permian–Triassic produced a breach between two major isolated faults (Faults ET2 and Fault MC1) in the central part of the EISB to generate a relay ramp structure. In the southern Irish Sea Basin, the Tournasian carbonate platform margin has a dip of 15 degrees, while the top Visean carbonate has a 37 degrees dip-angle on its margin. Thickness and shape of the platform varied between 600 to 1000 ms (c 1.5–2.5 km) in the southern and eastern parts of the basin. The deepest part of the platform, in the southern area, extends basinwards for around 5 km, but then backsteps in the upper 700 ms, implying that it could not keep up with relative sea level. Results also show that the platforms that formed on the footwall of normal faults and horst blocks survived for the longest time period, although they reduced in size. The faults have different displacement and throw variation, ranging from lower scale (0 to 100 ms), medium scale (100 to 300 ms), and major scale (300 to 550 ms). This tectonostratigraphic architechture could provide important insights into how the platform developed as faults propagated, interacted and linked and could have an implication to fluid flow.

Theme 14. Tectonics and sedimentation

General Session

Oral presentation

Sequence stratigraphy of the Pliocene–Pleistocene infill in the southern part of the Adriatic foredeep system

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The evolution of the foreland basin sediments in the Adriatic (Messinian–Quaternary) foredeep system was controlled by the Meso and Neoalpine emersed chain. Croatia's southern part of this system comprises the Palagruža Trough and South Adriatic Basin filled with marine clastic succession. Our study, in this area, aims to reconstruct the shelf-edge trajectories and sequence stratigraphy to describe the migration of the depositional systems. The study integrates published geological maps, well logs and reports, and 2D seismic sections. Mappable seismic facies are defined and correlated with sedimentological facies and depositional processes. Both, ascending and descending shelf-edge trajectories are defined. Ascending trajectories are associated with transgressive and highstand system tracts. Descending trajectories are associated with forced regression and the presence of extensive erosional surface on the shelf. Overall progradation characterizes Pliocene and Pleistocene sediments, first filling the Palagruža Trough in the SW direction and then SE progradation towards the South Adriatic Basin. The progradation pattern is interrupted by a base-level rise at the end of the Pliocene. Analysing the main sediment transport directions, the two third-order unconformity-bounded stratigraphic units are interpreted. Especially interesting are results about nearby Pliocene–Pleistocene clastic depositional systems and processes that shaped the southern part of the Adriatic Sea. These results highlight the stratigraphic and tectonic evolution of the Adriatic foredeep's southern part, providing the records of the regional and global controls driven by the local tectonics and emersion, basin migration and subsequent basin infill.

Theme 14. Tectonics and sedimentation

General Session

Oral presentation

The propagation of the 1693 tsunami wave in Catania, Italy based on multiple scenario simulation

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On January 11, 1693 tsunami waves caused by an Mw = 7.4 earthquake struck across the east to the southeast coast of Sicily including Catania, Augusta, Syracuse, and Marzamemi. As a consequence, it was speculated that these tsunami waves caused the deaths of 60,000 people across the eastern coast of Sicily and inundated Mazzini Square and agricultural areas around Catania. Simulations of the 1693 tsunami generation and the impacts of this tragedy in Augusta, Syracuse, and Ognina have been carried out by researchers, but an analysis of the height and propagation of the tsunami waves in Catania as the second largest city in Sicily has not been undertaken. Therefore, this study aims to describe the wave propagation of the 1693 tsunami when it reached the coast of Catania based on multiple scenario simulations. Six fault displacement scenarios in the Ionian Sea, east of Catania were plotted on the Delft Dashboard to obtain earthquake magnitudes. Wave propagation simulation while offshore was performed using Delft 3D-Flow. Arrival time and run-up of tsunami waves were inputted into ArcScene to create a visualization of tsunami wave inundation in Catania. The simulation illustrated that the projected magnitude of the earthquake east of Sicily was between Mw 6.38–7.18. The earthquakes that are likely to generate tsunamis are those with Mw>7, the estimated maximum run-up height is 5.9 m with an arrival time of about 15 minutes after the earthquake occurred. This study concludes that the predicted run-up height and arrival time of tsunami waves on the east coast of Sicily depends on the earthquake focal mechanism.

Theme 14. Tectonics and sedimentation

General Session

Poster presentation

Reconstruction of palaeoclimate of Shyok Valley to understand glacial dynamics using Optically Stimulated Luminescence (OSL) dating method

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Shyok Valley of Ladakh in Karakoram region is a consequence of multiple glacial events that resulted in the formation of depositional landforms such as moraines, outwash terraces, alluvial fans and lacustrine deposits. The preliminary tests of morphometry were carried out to understand the perturbations in the swath profile using Topotoolbox. A better insight of the glacial dynamics was obtained by collecting samples (sand lenses) in the field which were used as proxy for Optically Stimulated Luminescence (OSL) dating method. The detailed lithology of Khardung present at the confluence of Nubra and Shyok valley, Chalunka, Changmar in the lower Shyok valley and Agham village in the upper Shyok valley were recorded to understand the processes and the depositional environment that prevailed in the Quaternary period. The glaciofluvial deposits of ~25 ka at the bottom and youngest moraine of ~6 ka at the top stratigraphy of the Khardung sequence is suggestive of the fluctuations in the glacial events. The middle sequence of the former has age of ~18 ka which corresponds to the Last Glacial Maximum (LGM) followed by the post LGM lake formation that dates back to ~12 ka. The bottom layer of the Agham sequence consisting of glaciofluvial deposits (~18 ka) is indicative of the beginning of warming and deglaciation in the valley. The ages obtained from the outwash plane of Chalunka (~13.2 ka, ~ 6.0 ka, ~ 2.0 ka) and the deposition of lateral moraines at Chalunka (~14.0 ka, ~ 5.8 ka, ~0.4 ka) are in agreement with the Holocene period. The interbedded clay within sand layers at the Changmar village suggest ponding and the calm conditions whereas gravel and glacio-fluvial material, forming the remaining part of the straitigraphy, signifies the high energy environment.

The present study, therefore, probably explains the sediment deposits formed from the glaciation and deglaciation process and the presence of the glaciofluvial deposits that possibly might have blocked the Shyok river. The proposed enhancement of the glaciers is evidently due to the enhanced mid-latitude westerlies in MIS-2 (LGM) and mid-Holocene as a byproduct of the increase in moisture and decrease in temperature. The ponding, breaching and flooding in Shyok valley could have resulted in the formation of these depositional features which are indicative of glacial dynamics.

Theme 14. Tectonics and sedimentation

General Session

Poster presentation

Interplay between extension, salt-tectonics and sedimentation in a proximal rifted margin (Basque–Cantabrian Basin, westernmost Pyrenees)

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In complex geological areas where tectonic inversion has masked the syn-extensional rift margin structure, stratigraphic architecture and facies distribution, it is crucial to understand the behaviour of salt deposits and its influence in both, extensional tectonics and subsequent basin inversion. In the northeastern margin of the Basque–Cantabrian hyperextended basin (around the Palaeozoic Cinco Villas massif), the outcropping syn-rift upper Albian to lower Cenomanian deposits record high lateral facies and thickness changes due to extensional tectonics and the development of highly subsiding 3–5 km wide minibasins above basement blocks. In fact, evidence of folding, uplift, erosion and sedimentation of pre- to syn-kinematic deposits around salt-cored forced-folds have been described. This tectonic pattern resulted in the deposition of four different depositional systems in less than 20 km parallel to the Cinco Villas massif margin. In the eastern and southern sectors, on the hanging-wall of the basement-bounding main faults, a coarse-grained braidplain delta system developed. However, the growth of syn-sedimentary forced-folds controlled facies distribution and permitted the development of a carbonate platform on top of an anticline. This system laterally evolved into deltaic facies to the west. In the western sector, the highly subsiding Lasarte sub-basin registered in its northern margin toe-of-slope megabreccias eroded from a halokinetic forced-fold, and to the westernmost margin, a coarse-grained turbiditic system developed. Therefore, this study illustrates how the presence and halokinetic movements of pre-rift Triassic evaporite-rich mudstones (Keuper facies), conditioned accommodation space, bathymetry and thus, depositional systems in the area. Salt movement was triggered by basement normal faulting, creating salt walls along basement faults, which delimited adjacent depocentres or minibasins.

Theme 14. Tectonics and sedimentation

General Session

Poster presentation

Subsidence analysis of the Cantabrian Zone Foreland Basin (Carboniferous, NW Iberia)

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The Cantabrian Zone foreland basin developed on the northern Gondwana passive margin during the Devonian–Carboniferous Pangea assembly. The synorogenic basin infill is mainly exposed in the Cantabrian Zone, the foreland fold-and-thrust belt of the NW Variscan Iberian Massif, and shows the classic flysch-to-molasse evolution: 1) thin widely-distributed distal foreland-margin strata; 2) up to 6000 m-thick foredeep succession evolving from deep-water facies, comprising mélange carpets linked to submarine thrusts, to shallow-water, coastal and alluvial deposits; and 3) unconformable wedge-top successions. A subsidence analysis was performed on 11 stratigraphic sections, exposing from distal-foreland to foredeep and wedge-top strata, and aligned along a ca. 322 km long, palinspastically restored transect, parallel to the eastward direction of nappe emplacement. Tectonic and total subsidence were calculated for all studied sections using the OpenFlow™ software (Beicip–Franlab). A conceptual bathymetric model based on a complete sedimentological database allowed the reconstruction of the water depth over time. Subsidence models done for sections with high-relief microbial-dominated carbonate platforms that developed during early–middle Pennsylvanian in distal areas of the basin were used to check bathymetric estimations in adjacent sections for an underfilled basin stage. All sections yield the typical foreland-basin tectonic subsidence curves, with a convex-up profile and inflection points progressively younger towards the foreland that record the diachronous onset of subsidence rate breaks. Low subsidence rates (<0.01–0.13 mm/yr^{-1}) are recorded for the mainly pelagic and hemipelagic distal foreland margin strata that characterize the underfilled stage over the basin transect. Progressively higher subsidence rates (>0.20 mm/yr^{-1}, reaching up to 0.40 mm/yr^{-1}) record the foredeep infill until reaching the overfilled basing stage. Finally, unconformable late Pennsylvanian deposits, mostly marine (frontal reaches) to alluvial (rear parts), attest significant subsidence in the wedge-top areas until the end of Carboniferous. The obtained subsidence patterns will be key to link the basin development with the evolution of the Variscan fold-and-thrust belt.

Theme 14. Tectonics and sedimentation

General Session

Poster presentation

Topographic response to invasion: the Ordos Loess Plateau, Central China

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The Neogene to Recent Ordos Loess Plateau is an uplifted but internally stable crustal block on the eastern fringe of the Tibetan Plateau. It is one of the most severely eroded places in the world because of the weak loess. The Ordos Loess Plateau was a protection against the invasion of foreign nomads from the north in Chinese history due to its inaccessibility. It represents a deeply incised river landscape, mainly formed by the Jinghe and Luohe drainage systems. We found that the shape of the longitudinal channel profiles of the Jinghe and Luohe rivers are different from normal concave channel profiles, which are straight and deviate from usual graded longitudinal channel profiles over substantial portions. We hypothesize that this phenomenon may be related to the activation of the boundary faults around the Ordos Loess Plateau caused by the Cenozoic uplift of the Tibetan Plateau. To quantify the influence of uplift gradients on topography, we carried out (a) extensive field surveys, (b) a digital elevation model-based analysis of topographic properties, and (c) compiling and integrating data on exhumation, uplift, subsidence, and denudation from numerous previous studies. Morphological analysis shows that the southern boundary faults of the Ordos Loess Plateau are still tectonically active. We further found that there are typical table-lands distributed on both sides of rivers, especially in the Jinghe drainage area. This phenomenon illustrates that the degree of erosion and plateau incision is pronounced in the eastern part of the Ordos Loess Plateau, while the southwestern part is less incised. The evidence from swath profiles also demonstrates that the drainage basins are tilted toward the Liupanshan Mountains overthrust in the southwest. We conclude that due to the ongoing India–Asia convergence, the northeastward expansion of the Tibetan Plateau led to the eastward lateral extrusion of fault-bounded blocks, which were stopped by the craton-like Ordos Loess Plateau along the Liupanshan fold-thrust zone. The activation of the southwestern and southern boundary faults around the Ordos Loess Plateau led to the southward draining direction of the Jinghe and Luohe Rivers towards the Weihe Graben and formed anomalous longitudinal channel profiles, which continue to cause serious soil erosion.

Theme 14. Tectonics and sedimentation

General Session

Poster presentation

Thermal evolution of the Permian Claromecó foreland basin (southern Gondwana, Argentina) based on organic petrology and basin modelling

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Understanding the geology of the Claromecó foreland basin (Buenos Aires province, Argentina) is key to improve the knowledge of the paleotectonic and paleogeographic evolution of southwestern Gondwana. Due to the presence of subsurface coal beds and potential gas accumulations the understanding of this basin is also relevant to the exploration of energy resources in Argentina. This study aims at reconstructing the thermal and burial history of the Claromecó Basin, by means of organic petrology and thermal modelling. Organic petrography analyses were performed on core samples from the Tunas Formation (Permian). Vitrinite reflectance data (%R_o) were obtained and used to calibrate thermal modelling. Calibration was also corroborated by fluid inclusions and apatite fission tracks data from previous works.

Samples analyzed correspond to organic-rich shales and coals with total organic carbon values ranging from 0.3 to 60 wt%. Carbonaceous levels are mainly composed of inertinite and vitrinite macerals and solid bitumen. Vitrinite reflectance data range from 1.63 to 2.8%, with an average of 1.9–2.3%. This large variation is related to the great difficulty to distinguish vitrinite from semifusinite (inertinite). The minimum values obtained (1.65 to 1.90%) were measured on very small particles, which could correspond to vitrinite. Thus, the largest population measured (>2%) could be semifusinite. Therefore, wet to dry gas window thermal conditions (1.6–2%) are estimated for the Tunas formation, and are consistent with paleo-thermal indicators previously obtained (fluid inclusions and mineral associations).

Thermal modelling results indicate that in order to calibrate vitrinite reflectance values, an erosion of around 3500 m and a heat-flow peak of 100 mW/m^2 at the maximum burial time, is necessary. Based on the previous geodynamic and tectonic reconstruction of the Claromecó Basin, we suggest that the maximum temperature estimated for the Tunas Formation was reached in the late Permian–Triassic, during the latest phase of the Gondwanides Orogeny, when a section of around 3000 meters was deposited, considering a geothermal gradient of 50°C/km. In the Mesozoic follows the uplift of the basin infill that could be associated with the South Atlantic rift stage, resulting in the erosion of at least 3000 m of sediments.

Theme 14. Tectonics and sedimentation

General Session

Poster presentation

Organic matter from clastic injectites in the Menilite Beds of Poland, Ukraine and Romania (Outer Carpathians)

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The Menilite Beds are widespread in most tectonic units of the Polish, Ukrainian and Romanian Carpathians and are dominated by brown and black shales, and mudstones. The unit comprises also bituminous marls, cherts, limestones, diatoms, sandstones and conglomerates. The occurrence of clastic injectites (mainly sandstones), traditionally termed "dykes", was observed in the Menilite Beds of the Polish (Skole and Silesian Unit), Ukrainian (Boryslav–Pokuttya Unit) and Romanian (Vrancea Unit) Outer Carpathians. The dykes occur at various scales (from several millimetres to several metres) and have variable lengths. Two types of dykes were recently distinguished: 1) type S injectites (formed during post-sedimentary processes) and 2) type T injectites (strongly tectonized). During field investigations, lithological–sedimentological logs of exposures were prepared and samples from dykes, host rocks and sometimes from potential parent bodies were collected. Field observations were supported with microscopic analyses, including a micropalaeontological study of selected samples, palynofacies analysis and UV excitation. Organic matter was identified in both types of injectites. Typically, the organic matter from the dykes is characterised by different properties than the organic matter from the host rocks. Low diversity of particulate organic matter components and domination of yellow and orange amorphous organic matter (AOM) were observed in transmitted light in host rock samples. In turn, organic matter from the clastic injectites is characterised by higher diversity and lower abundance of AOM (e.g. Kobielnik – relatively high content of phytoclasts, mainly opaque, and low content of dinoflagellate cysts; Futoma – high content of sporomorphs). These observations show that clastic material from dykes originated in lithostratigraphic units other than the Menilite Beds or the organic matter is mixed, being derived from various units.

Theme 14. Tectonics and sedimentation

General Session

Poster presentation

Cenozoic massive carbonate breccia in the External Dinarides of Croatia: the largest outcrop on the island of Krk

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The Cenozoic carbonate breccias in the External Dinarides, known as Jelar deposits or Velebit breccia, have been puzzling geologists for decades. The timing and formation mechanisms of this interesting lithological unit is still debatable.

The largest breccia outcrop on the Adriatic islands is located on the southeasternmost part of the island of Krk, on the karstic plateau between Stara Baška and Draga Bašćanska. Approximately 11.5 km long and 350 to 1300 m wide outcrop of a typical Dinaric strike (NW–SE) was studied by detailed geological mapping, structural measurements and sampled along the profile normal to the structure.

The breccia outcrops are massive, mostly clast-supported, mostly lacking sedimentary structures. Clasts are unsorted and typically angular, ranging in size from sand to gravel, with rare cobbles and boulders. Clasts are mainly derived from adjacent lithostratigraphic units, many showing calcite-filled fissures, indicating intense tectonics prior to deposition. Clast contacts are commonly characterized by pressure solution, while grey, whitish, yellowish to reddish matrix mostly consists of finely crushed limestone particles or coarse-crystalline calcite grains. Rare small-sized sedimentary bodies rich in matrix with numerous rounded clasts indicate local fluvial transport prior to deposition.

Most of the breccia outcrops are located in the hinge zone of the NE-verging overturned anticline (a tectonic transport not common in the Dinarides but typical for all Cenozoic carbonate breccia zones). Along the studied profile, the contacts between breccia and the surrounding rocks are steep but gradual. In most places transition zones from (i) limestones to (ii) tectonized limestones to (iii) cataclastic limestones to (iv) monomict and/or polymict breccia can be several meters wide.

Results of studied breccia outcrop suggest that breccia formation probably onset during the late stage of the principal Late Eocene–Oligocene Dinaric compressional phase by disintegration of source rocks into small-sized clasts. Subsequent localized extension in the hinge of the overturned large-scale anticline created a series of deep canyon-like fractures filled by a large quantity of clasts lithified by mosaic calcite cement.

Theme 14. Tectonics and sedimentation

General Session

Poster presentation

Carbonate platforms in the Variscan foreland basin of the NW Spain: a tool for quantifying tectonic flexure, accommodation and sedimentation rate

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The nucleation, growth and demise of carbonate platforms in foreland basins are controlled by intrinsic and extrinsic factors 1) net carbonate production, 2) orogen-fed terrigenous input and 3) changes in accommodation. Variations in subsidence rate ahead of the orogenic front mainly reflect the flexure of the foreland lithosphere due to loading by both the advancing orogenic wedge and the sedimentary infill. Lower–Middle Pennsylvanian microbial carbonate platforms formed in the Variscan foreland basin of Northern Spain, which developed on the southern flank of the Laurentia–Gondwana collision. These systems grew both on the distal foreland margin and on the proximal foredeep delta-fed siliciclastic wedges, and therefore their study over proximal–distal-oriented transects allows the reconstruction of the Gondwana lithosphere flexure during orogeny. Growth styles, relief above the adjacent seafloor and thicknesses of the carbonate platform systems from the distal foreland margin, studied along a 42 km-long transect, permit constraining the lithospheric flexure during the underfilled basin stage (Early Pennsylvanian). Rates of orogen-ward tilting of the basin floor increased gradually from 0.24°/Ma to 0.38°/Ma, creating the accommodation that allowed the growth of up to 1500 m-thick steep and high-relief isolated carbonate platforms and buildups. These systems display aggradational growth styles with limited platform-margin progradation and were progressively onlapped and buried by the siliciclastics infilling the foredeep. In the proximal foredeep, delta-top carbonate systems provide insights into major trends of terrigenous supply versus accommodation and lithosphere flexure along the delta-built marine shelves closer to the orogenic front. Reconstruction of stratal geometries after sediment decompaction along a 170 km-long cross section, corrected for Variscan deformation, reveals rates of orogen-ward tilting ranging from 0.47°/Ma to 0.67°/Ma during the Middle Pennsylvanian, and total subsidence rates up to ca. 0.7 mm/yr.

Theme 14. Tectonics and sedimentation

General Session

Poster presentation

Tectonosedimentary variations from Permian to Triassic in the southeastern part of the Central Graben of the Norwegian continental shelf

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The aim of this study is to explain the differences in distribution, geometry and sedimentological variations of the Triassic Smith Bank and Skagerrak formations with the Permian Rotliegend Group across the Central North Sea on the Norwegian Continental Shelf. Two fault families interpreted from seismic data show contrasting influence on the thickness variation of the Rotliegend Group deposits and the salt tectonic activity, which ultimately affect the development of minibasins, in which the Triassic sequences were deposited. NW–SE-striking faults in the west were active after the deposition of the Rotliegend Group and did not affect the minibasin geometry. On the other hand, the Hummer fault zone, a NNW–SSE-striking fault located in the eastern part, was coeval with Permian deposition and played a major role creating accommodation space and affecting the geometry of the salt. The shift in fault strike in the eastern sector imprints a change in the shape of the Triassic minibasins, suggesting a tectonic control on sedimentation. Well log and core data from six wells show significant continental facies variations between the upper Permian and the Triassic in the study area. The Rotliegend Group consists of coarse material and rather uniform sequences, with little evidence of lacustrine deposits and a high gamma-ray marker at the top belonging to the Kupferschiefer Formation, observed in all the wells. Differently, Triassic deposition was restricted to minibasins, making regional correlations challenging. The lithology of the Smith Bank and Skagerrak formations in the cores is mainly fine sandstone to siltstone, but occasionally also conglomerate. The material is interpreted to represent fluvial to lacustrine environments. In addition to seismic data, micro faults are observed in sandstone from core samples within the upper Rotliegend Group in the SW. They probably formed shortly after deposition and could represent a mesoscale example of faulting involving upper Permian deposits. Further analysis from core samples will be completed to understand microscopic variations and provenance. Our preliminary conclusion is that, generally, the upper Permian was more tectonically quiescent and that Triassic minibasins were controlled and shaped locally by salt tectonic activity in low energy conditions.

Theme 15. Sedimentology and hydrocarbons

Special Session 15.1. Seismo-sedimentological characterization of 3D seismic data

Oral presentation

Seismic geomorphology of Pannonian clastic reservoirs in Drava and Zala Basins, Pannonian Basin System

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Mature basins provide a wealth of data for the reconstruction and mapping of their sedimentary evolution and architecture as well as regional paleo-geographic changes. In turn, these often lead to a better understanding of geological processes and thus provide a basis for novel concepts in exploration of subsurface. The Neogene Pannonian Basin System (PBS) nested between the Dinarides, Alps and the Carpathian arc in Central Europe is such a mature area with more than a century hydrocarbon exploration and production history. The upper Miocene to Pliocene sediments, referred to as Pannonian Stage, were initially deposited in an under-filled lake basin displaying gradual transgression followed by a powerful regression characterized by prograding and aggrading clinoforms on reflection seismic data. Relative chronostratigraphic framework was defined by clinoform sets mapped along with their rollover points across Drava and Zala basins. Based on seismic attributes, log patterns and available core data, clastic depositional features and architectures were delineated across different depositional environments within lake basin clinoforms. Each depositional feature is described upon its position within clinoforms, type of clinoform trajectory and typical log pattern. Finally, depositional features are described in their typical sizes (based on 3D seismic data) and reservoir quality. Integrating various data resulted in more complete temporal and spatial development of depositional environments during clinoform deposition as well as depositional features. Mapping of the depositional features across clinoforms resulted in considerable range of reservoir sandbody types that can be recognized on 3D seismic within Pannonian Basin System.

Theme 15. Sedimentology and hydrocarbons

Special Session 15.1. Seismo-sedimentological characterization of 3D seismic data

Oral presentation

Seismo-sedimentological characterisation of Neogene successions in the Vienna Basin for exploring geothermal energy

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During the current trend of energy business transition, many stratigraphic intervals are being re-evaluated for low-carbon energies. This study represents two such cases from the Neogene succession of the Vienna Basin, Austria where seismo-sedimentological workflows have been utilised for constructing gross depositional environment (GDE) maps towards exploring geothermal resources. In this study, the existing cores and well logs are sparse and of vintage quality, although a recent 3D seismic survey exists. Current poor-quality state of these historical cores proved inadequate to make detailed sedimentological descriptions required for facies analysis and facies models. As a consequence, identified seismic features have been assigned first to a specific environment/architectural element, and then compared with the sporadic sedimentological data collected from cores, cuttings and logs. Seismic reflector patterns such as onlap, offlap or downlaps provided first insights into the stratigraphic setting, however, subtle features were better observed with spectral decomposition combined with stratal slicing. For depositional system interpretation of seismic features, spectral decomposition data were projected on to geological time-consistent horizons (‘horizon stacks’). This approach proved to be effective in extrapolating the interpretation in areas with no or limited well control by using stacks of ‘horizon slices’ combined with spectral decomposition data. An overlay of several such nearby horizons were made transparent to increase resolution and visibility. The depositional system interpretation was corroborated locally with sedimentological data such as lithology, texture, composition, sedimentary structures obtained independently from cores and cuttings. Furthermore, trends in SP-log pattern were used to assess gross lithology changes. Among the studied succession, four GDE maps were constructed in total, which, in combination with petrophysical and thermophysical datasets, suggested a variable potential of geothermal energy exploitation in the study area. These maps also enabled in narrowing down and ranking the area of interest into sub-areas with the highest geothermal energy potential for the next phase of detailed evaluation.

Theme 15. Sedimentology and hydrocarbons

Special Session 15.1. Seismo-sedimentological characterization of 3D seismic data

Oral presentation

Seismic characteristics of the Miocene section in Northern Song Hong Basin, offshore Vietnam: suggestion to predict depositional environment and potential hydrocarbon stratigraphic trap

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The Song Hong sedimentary basin is a Tertiary pull-apart basin, which was subdivided to Northern, Central and Southern parts. Unlike the Central and Southern parts of the basin where are characterized by a relative stable tectonic regime, northern Song Hong basin experienced a very strong inversion during the Late Miocene; This rapid uplift of the region has led to significantly change in lithofacies and sedimentary environments. This complex geological setting is considered one of the most challenging in prediction of the hydrocarbon traps in the region.

Based on a relatively large covering of 2D and 3D seismic and drilled wells, depositional environment characteristics of the potential hydrocarbon reservoir was defined. The recent results derived from seismic interpretation allowed us to define the Miocene formation, which are subdivided into three substrata, consisting of the Lower, Middle and Upper stratum. These substrata are characterized by typical characteristics of lithology and depositional environments; The formation of Lower Miocene was influenced by marine transgression with the lithologic showing of fining upward and shale-dominant deposit, varies from coarse-grained sediment (sandstone) to fine grained material such as shale and mudstone upward; deltaic environment observed at the bottom, transitioning to the overlying shelf environment. The Middle Miocene stratum demonstrate sandier, coalic materials of the delta plain and delta front environments intercalated with swampy shale. Coal formation was only observed in the lower part whereas incised channel systems were strongly developed in the upper part of the Middle Miocene section. Fluvial delta plain and nearshore elements becomes dominant in the Upper Miocene section. It is illustrated by presence of the channel-filled sand bodies and mouth/longshore sand bars. These characteristics of Miocene depositional environment suggest good porosity and horizontal permeability that could be potential of both hydrocarbon structural trap and stratigraphic trap in northern Song Hong basin, such as sand bar, channel fill and pinch-out, locating along channel/eroded zones of delta plain and on the western and eastern flank of the basin.

Theme 15. Sedimentology and hydrocarbons

Special Session 15.1. Seismo-sedimentological characterization of 3D seismic data

Oral presentation

Pannonian turbidites on a topographically complex slope as exploration targets in the Zala Basin

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The most prolific hydrocarbon reservoirs in the Neogene petroleum system of the Pannonian Basin are the deltaic sands and the deep-water sand bodies deposited in Lake Pannon. The prediction of thickness and reservoir quality of the turbidites is therefore of critical importance for hydrocarbon exploration. The objective of our study was to create a complex sedimentological model of the Late Miocene turbidites in the Zala Basin, western Hungary. Using two 3D surveys, a set of 2D seismic lines, core data and well logs, we reconstructed the paleotopography, the slope advancement in space and time, analysed the factors of confinement, and applied amplitude maps and spectral decomposition maps for seismic geomorphology. The study area within the Zala Basin was filled by the southward prograding "Paleo-Danube" sedimentary system with W–E trending shelf-edge slope. The 3D seismic captures the upstream part of a gentle antiform quasi perpendicular to the slope progradation. The turbidite system was made up of a variety of architectural elements: straight, small-scale canyons, single sinuous channels, wide channel belts, crevasse splays, intraslope lobes, overbank deposits, channelized lobes, and terminal lobes. The oblique-frontal confinement by the pre- and synsedimentary, long wavelength antiform was controlling sand deposition. Deflected channels, very high sinuosity channels, wide channel belts with lateral migration and avulsion, and intraslope lobes were deposited in front of the high with good reservoir quality. The high has fewer and lower sinuosity channels that bypass sand during aggradation to a downstream basin outside the 3D data. Irregularity of the prograding shelf-edge slope created lateral confinement of toe of slope turbidites, resulting in straight aggrading channels and cross-cutting channel patterns. These reservoirs may form prospective stratigraphic traps especially when lateral sealing is provided by pinch-out or shale-out due to frontal or lateral confinement. The prospectivity of this play is confirmed by the discovery of the relatively small but commercial gas pools of Tófej, Gutorfölde and Rádiháza.

Theme 15. Sedimentology and hydrocarbons

Special Session 15.1. Seismo-sedimentological characterization of 3D seismic data

Oral presentation

Reconstruction of the Upper Miocene deposits in the southeastern part of the Pannonian Basin, based on seismic, well log and sedimentological data

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Upper Miocene deposits in the southeastern part of the Pannonian basin can be separated in three sedimentary and tectonic cycles. First cycle is represented by deep-water marlstones, claystones and sandstone turibidites of regional Endrod and Szolnok formations. Above them, the second cycle sediments are deposited in a delta plain environment which is represented by clastic and marly deposits of progradational series of Algyo formation. Finally, above this progradational series there are sedimentary deposits of shallow water, transitional and terrestrial environments of Ujfalu formation. Primary goal of this research was to confirm the direction of progradations and isolate sedimentary bodies of Upper Miocene with different lithological characteristics. The main challenge during this process was the geological characterization of seismic data, which is usually in time domain and has a vertical resolution significantly lower than well data. Detailed lithological analysis of the wells was done using the method of cluster (lithotype) analysis of well logs. Cluster analysis of well logs is based on the recognition of similarities or differences in the physical characteristics of drilled rocks, in order to group them into clusters or electrofacies. Taking into account that the seismic data is also a reflection of certain changes in the physical characteristics of the rocks, the cluster analysis in combination with seismic facies maps, represents an excellent input parameter for the formation of the initial 3D lithofacies model. The goal of this analysis was to create seismic facies maps which will, combined with lithotype analysis results, fill the petroleum system model with data on lithologies and their spatial distribution. After calibration, the final lithology facies maps are obtained. Multi-disciplinary research also included the analysis of sedimentary bodies that were separated by using interpreted horizons and seismic attributes. The examined segment of the sedimentary series stratigraphically belongs to Upper Miocene–Pliocene age (second and third cycle deposits). Using two seismic attributes, “mean amplitude” and “RMS amplitude” it was possible to define some of the sedimentary bodies in this environment and confirm their characteristics based on the lithotype analysis results.

Theme 15. Sedimentology and hydrocarbons

Special Session 15.1. Seismo-sedimentological characterization of 3D seismic data

Keynote lecture

Three-dimensional seismic analysis of geomorphological features on early post-rift sequence of Mura Basin (Neogene Pannonian Basin System, Croatia)

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Mura basin, located in the SW part of the Pannonian Basin System, with extensional rift graben/half-graben architecture holds typical transgression to late regression record – sedimentation catches up with the decreasing subsidence ("catch up" infill). Seismo-geological interpretation of the basin starts with syn-rift phase which lasted from the Ottnangian until the middle Badenian, followed by early post-rift phase which lasted from middle Badenian until the Sarmatian. Finally, basin is developed by late post-rift phase from the Pannonian to the Quaternary. Tectonic–sedimentary architecture of Mura graben is controlled by interaction of footwall, hangingwall and axial-derived depositional system. While the tectonic component of footwall upthrown block holds major HC fields/discoveries, the sedimentological component in the hanging-wall basin is still insufficiently explored and represents a potential that can be revealed by introduction of new stratigraphic plays. Hanging-wall Mura graben as main depocenter recorded extensive early post-rift deposits. Early post-rift system tract, deposited in-between Middle Miocene and base Pannonian unconformities, is controlled pre-dominantly by climate (Middle Miocene Climatic Optimum) and eustatic fluctuations of Central Paratethys and its connection with Indo-Pacific Ocean. Resulting transgressive sequence disconformable overlies inverted Lower Miocene structures made of coarse-clastic and volcano-clastic deposits. Seismic facies analysis of 3D seismic data, calibrated with well logs and core data, revealed seismo-sedimentary geobodies that can be classified as shallow marine carbonate reefs, rock fall deposits, high energy shoals, fan deltas, sediment wave shales and basin turbidite lobes. This study would like to highlight/summarize favourable geological setting for stratigraphic entrapment of these reservoir geobodies and will serve as basis for new stratigraphic play definition in the mature PBS.

Theme 15. Sedimentology and hydrocarbons

Special Session 15.1. Seismo-sedimentological characterization of 3D seismic data

Oral presentation

Seismic diagenetic facies prediction of tight sandstone in the offshore sparse well area: an example from the Xihu Depression of the East China Sea Basin

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The purpose of this study is to forecast the spatial distribution of diagenetic facies (DF) of tight sandstone in the offshore sparse wells area. Analytical test data, rock physics experiment data and prestack seismic data were used to study the spatial distribution of seismic diagenetic facies (SEISDF) of tight sandstone of the second (H4b) submember of the fourth (H4) member of the Huagang (E3h) Formation in the N gas-field, Xihu Depression, East China Sea Basin. Based on diagenesis and diagenetic minerals, core-based DF of the H4b sandstone were divided into chlorite-coated facies (CHF), calcite-cemented facies (CAF), dissolution facies (DIF), tightly compacted facies (TIF), and quartz-cemented facies (QUF). Various seismic elastic parameters were obtained by prestack elastic parameter inversion method, and sensitive seismic elastic parameters were selected according to the seismic identification principle of DF. Four DF and sensitive seismic elastic parameters were integrated to establish a SEISDF prediction model based on supervised learning, and obtain a diagenetic facies comprehensive index (DFCI). Then, 90° phase conversion technique of seismic lithology was used to realize the consistency of the DFCI between isochronous stratigraphic interfaces with core-based DF. Stratal slicing technique of seismic geomorphology was used to make the stratal slices of the DFCI between isochronous stratigraphic interfaces. Representative stratal slices were singled out, and the spatial distribution of the SEISDF was interpreted. This study shows that the H4b1 sublayer primarily develops the TIF, while the H4b2 and H4b3 sublayers chiefly develop the QUF, CHF, and DIF. Compared with the H4b2 and H4b3 sublayers, the areas of the QUF and DIF in the H4b4, H4b5, and H4b6 sublayers slightly increase. The QUF are mainly distributed in the subaqueous distributary channel and a small number of sheet sand and channel bar depositional facies in the form of continuous sheets. The CHF are primarily developed in lenticular shape in the channel bar and a small amount of sheet sand and subaqueous distributary channel depositional facies. The most favorable DIF are chiefly developed in the subaqueous distributary channel, channel bar, and sheet sand depositional facies near the fault, which are distributed in strips.

Theme 15. Sedimentology and hydrocarbons

General Session

Oral presentation

Fluid activity and diagenetic response during tectonic inversion and its impact on reservoir quality and gas accumulation

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Inversion tectonics are of paramount importance for forming a range of hydrocarbon traps and reservoirs for petroleum exploration. Also, the uplift and exhumation of strata, the activation and creation of faults and leakage or breaching of hydrocarbon traps are often attributed to or multiple inversion. The fluid activity and geochemical system change easily during tectonic inversion. However, the detailed impact of tectonic inversion on fluid flow and possible diagenetic alteration in deeply buried sandstone remain unclear, which restricts the evaluation of reservoir quality and further oil and gas exploration. The Oligocene fluvial–deltaic sandstones of the Upper Huagang Formation in the Yuquan tectonic zones of Xihu Depression were characterized by intense alteration and dissolution of detrital grains, especially the plagioclase grains were completely dissolved, accompanied by a large number of authigenic kaolinite and quartz grains. Due to the late fault caused by structural inversion cutting through the caprock and communicated with the reservoir, the fluid was quickly discharged upward, which led to the enhanced export of some dissolution products. Although structural inversion promoted the formation of secondary pores to a great extent, it also caused upward leakage of oil and gas, resulting in relatively good reservoir quality but the overall gas saturation was low in studied area. Our research will help better understand the rock–fluid interaction and genetic mechanisms of gas reservoirs under different degrees of tectonic inversion, which support the predrill evaluation of the reservoir quality in deeply buried reservoirs, as well as other targets with similar backgrounds.

Theme 15. Sedimentology and hydrocarbons

General Session

Oral presentation

Mechanism of pore evolution during the diagenesis and hydrocarbon generation of marine carbonate-rich shale – insights from thermal simulation experiments

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In order to clarify the evolution of pore structure during the diagenesis–hydrocarbon formation process of marine organic-rich shales, taking the Devonian marine low-maturity carbonate-rich shales of the Yangzi plate in South China as the research object, a series of evolutionary samples from low-maturity to maturity stage and high overmaturity stage were obtained by simulating hydrocarbon generation experiments with hydrous semi-closed pyrolysis under near geological conditions. The FE-SEM, SEM, CO_2 adsorption and N_2 adsorption were used to qualitatively and quantitatively characterize the pore structure features of the simulated shale samples. The experimental results show that the carbonate-rich shale shows differential evolution of total oil, expulsion oil, retention oil and hydrocarbon gas yield with increasing temperature and pressure of the simulation experiment, and the total oil yield peaks at Ro=0.97%, which is also the maximum reservoir period for retained oil. Organic matter pores, intergranular pores, pyrite intergranular pores, intragranular solution pores, clay mineral interlayer pores, and shrinkage crack pores are the main reservoir space types. The pore volume and specific surface area show an increase and then decrease with the increase of thermal evolution, and then gradually increase to the maximum value and then decrease. Throughout the process, the pore volume of micropores and the specific surface area of macropores do not change much, while mesopores and macropores are the main contributors to the total pore volume, with more than 70% of the total specific surface area contributed by micropores and mesopores. Compaction, residual hydrocarbon plugging and filling, as well as mineral recrystallization, are the main pore-reducing effects of organic-rich shale, while organic matter hydrocarbon generation and dissolution of unstable minerals are the main constructive influences on pore development in marine carbonate-rich shale reservoirs. The organic matter hydrocarbon generation–expulsion–retention and diagenesis jointly influence the pore evolution characteristics of organic-rich shale reservoirs. The research results can provide theoretical support and guidance for the exploration and development of deep shale oil and gas.

Theme 15. Sedimentology and hydrocarbons

General Session

Oral presentation

The architecture of Cambrian reef-beach and their control on favorable reservoirs: a case study of Gucheng area in Tarim Basin, NW China

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The scale and quality of microbial carbonate reservoirs determine potential hydrocarbon exploration in the Tarim Basin, which depends on the type of carbonate platform and the scale of reef-beach. Based on big data of core, 3D seismic data, geochemical and other experimental data, the architecture of microbial reef-beach in Gucheng area of Tarim Basin and their control on favorable reservoirs are systematically discussed. The results show that: 1) Tarim Basin was a rimmed carbonate platform during Cambrian Miaolingian–Furongian, and there were four stages of microbial carbonate rocks in the platform margin. The architecture of Cambrian reef-beach is mainly controlled by the ratio between the rate of sea level rise and the growth rate of microbial carbonate rocks. There are two types of reef-beach in the Miaolingian–Furongian rimmed platform – accretion type and progradation type. During the Miaolingian it was the restricted rimmed platform, and the reef-beach of accretion type was developed. During the Furongian it was a partially restricted platform, with the development of progradational reef-beach. 2) The architecture of reef-beach controls the difference of reservoir physical properties. The aggradational reef-beach is controlled by sedimentary palaeogeomorphology, and the reservoir pores are more developed in the core and flat beach. The upper part of progradational reef-beach was strongly influenced by atmospheric water corrosion, and the reservoir pores are more developed at the top of the reef-beach ridge. 3) The characterization of reservoir pore-throat structure reveals that the reef-beach reservoirs have strong reservoir heterogeneity, and the types of pore structure are different. The core of reef-beach is characterized by high porosity and low permeability, with poor connectivity. The pore structure is more homogeneous and has better connectivity than core reservoir pore throat. Therefore, in order to improve the recovery rate of strongly heterogeneous reef-beach gas reservoir, the author suggests to use highly deviated wells or horizontal wells to improve the drilling rate of microbial reef-beach and beach ridge.

Theme 15. Sedimentology and hydrocarbons

General Session

Poster presentation

The application of CO_2 EOR techniques in the western part of Moesian Platform

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The application of Enhanced Oil Recovery (EOR) techniques is encouraged by the current oil price and the growing global demand for oil. Among them, carbon dioxide (CO_2-EOR) is a technology to improve oil production combined with geological sequestration. This method began to be associated with CO_2 geological storage in the past two decades. Although much of the CO_2 is recycled and reinjected for hydrocarbon production, a significant quantity of CO_2 is permanently stored in the reservoir. The most famous CO_2-EOR project is Weyburn–Midale CO_2 Project in Saskatchewan (Canada). In Romania, CO_2 injection experiments were designed for several oil fields: Bradesti–Bibesti–Balteni, Samnic.). The short CO_2 injection experiments were applied to wells in the following oil reservoirs: Bradesti, Bibesti, etc. Relating to the efficiency of the enhanced production from oil fields, the most favorable ones for operation by injection of CO_2 are located near sources of CO2 because the transport costs are relatively low. Bradesti and Balteni structures for example, positioned on the western side of the Moesian Platform, is very well explored until now concerning its hydrocarbon potential due to their specific geological conditions. Bradesti structure it consists of a dipping zone descending from north-northwest to southeast with a stratigraphical column specific to the Moesian Platform (Triassic, dogger, and Sarmatian), presenting all its main sedimentation cycles with cumulative thickness exceeding 6000–7000 m in most subsided areas. Depression deposits suffered during their evolution an important thermal metamorphism that enables a great part of them to generate hydrocarbons. This feature correlated with the specific structural arrangement provides the necessary conditions for the existence of exploitable petroleum accumulations. Such deposits are the structures Bradesti, Balteni, Bibesti, Samnic, and others. These reservoirs and sources can be considered as small regional industrial clusters on the whole CCUS (carbon capture utilisation and storage) chain can be implemented. Through the tertiary injection of CO_2 into the above-mentioned fields, we can estimate that extra production of 1 to 5 million tonnes of oil can be extracted per oil field over the next 20 years, so the increase in oil reserves could be 25 to 100 million tons. The geological formations (Triassic, Sarmatian, Meotian, etc.) which are suitable for safe storage and are marked with a high degree of geological and physical knowledge, are widely distributed in the country.

Theme 15. Sedimentology and hydrocarbons

General Session

Poster presentation

Miocene facies characterization and distribution in the Zalata–Dravica area (Drava Depression, Pannonian Basin, Croatia/Hungary)

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The Miocene Paratethys Pannonian basin evolution, from continental to lacustrine environment, is a challenging task because of the significant tectonic, paleoecologic and sedimentologic changes. In the Zalata–Dravica area, five key wells with numerous laboratory geological and geochemical analyses have been chosen. The obtained data were systematically collected, interpreted, and correlated with accessible well-log and seismic diagrams. The oldest Miocene sedimentation beginning with the syn-rift continental alluvial, talus and lacustrine deposits of lower Badenian. The sedimentary succession continues with marine deposits from the middle to the upper Badenian. During the uppermost Badenian, Sarmatian and lowermost Pannonian periods, shallowing and gradual decrease of salinity occurred, and the deposition condition became brackish. Interruption of sedimentation (hiatus) was recorded in places. At that time many stenohaline organisms disappeared and euryhaline organisms (prasinophytes) became abundant. The isolation of Paratethys from the world oceans together with drastic ecological change resulted in endemism which additionally complicated biostratigraphic correlation and age determination. The Miocene sedimentation continues with the upper Miocene calcite-rich marls, sometimes intercalated with locally derived coarse-grained gravity-flow sediments. With the deepening of the basin, due to thermal subsidence and the advancing of large river systems generally from the NW, a huge amount of clastic deposits entered the basin, filled it with prograding sandy sediments, turbidite, slope and delta deposits. Towards the end of the Miocene, the lake become freshwater. Consequently, biostratigraphical biozonation (palynozonation), chronostratigraphical correlation, petrographical and sedimentological core classification, depositional mechanism and environment definition have led to the facies interpretation and distribution (GDE maps) and creation of a sedimentological concept of the area as a base for a basin analyses. In that sense, organic facies, source rock, petroleum potential, maturity, and hydrocarbon correlation are defined, as well.

Theme 15. Sedimentology and hydrocarbons

General Session

Poster presentation

Sedimentary characteristics and oil-bearing of mixed shale in northern Dongying Sag, eastern China

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The mixed shale is widely developed in the upper member of the fourth member of Shahejie Formation in the northern Dongying Sag of Bohai Bay Basin, eastern China, which is a mixed sedimentary rock composed of alternating layers or interlayers of shale and carbonate layers. Previous studies on the sedimentary origin and oil-bearing properties of mixed shale are controversial. By utilizing core, well logging, mud logging, analysis, testing and other data comprehensively, the sedimentary characteristics and oil-bearing of mixed shale are studied systematically, and the sedimentary relationship and oil-bearing relationship of different lithology of mixed shale are clarified in the study area. The results show that: (1) The lithology is mainly composed of gray mudstone, gray shale, shale and marl, with a small amount of carbonate rocks and sandstone. The sedimentary material has fine particles and complex compositions, including clay, carbonate, quartz, feldspar, pyrite and organic matter (average abundance is 2.96%). (2) It is a semi-deep lacustrine – deep lacustrine deposit with complex hydrodynamic conditions, which laminae and bedding are extremely developed, mainly consisting of clay laminae, carbonate laminae, organic laminae and mixed laminae. There are several sets of thin limestone or sandstone in the shale, among which the (lamina) layered gray mudstone and sandstone interlayer are the most developed. The types of reservoir space are mainly inorganic pores and micro-fractures. The heterogeneity is strong, and a variety of lithofacies are cyclically superimposed vertically. (3) Mixed shale has high organic carbon content (TOC value is 0.66–13.04%, with an average of 3.43%) and sufficient oil source conditions. Compared with argillaceous limestone, gray mudstone has higher porosity and better oil-bearing. The carbonate-rich laminated shale is rich in free oil, which migrates and accumulates to its own shale reservoir and shallow reservoirs, showing “source and reservoir coupling and orderly accumulation”.

Theme 15. Sedimentology and hydrocarbons

General Session

Poster presentation

Lithofacies analysis of coarse-grained clastics using borehole image texture clasiffication and MRGC clustering method

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Available data for reservoir characterisation is usually limited to well logs and core analysis data. However, integration of a new methodologies can improve the understanding of reservoir properties and heterogeneity of reservoir rocks. One of these new methods is automatic electrofacies characterisation of reservoir rocks based on resistivity borehole image data. High resolution of these image data provides important information regarding sedimentology, porosity and, consequently, the permeability of the reservoir rocks. Such electrofacies classification was carried out for the Badenian coarse-grained carbonate deposits in one well in the eastern part of Drava Basin using Geolog software. The workflow for electrofacies classification consisted of (1) automated image texture classification and then (2) MRGC (Multi resolution Graph based Clustering) clustering method which identifies patterns/groups in data. MRGC output is classification curve that was then transformed through equations into electrofacies curves that reflect different reservoir characteristics. Seven electrofacies were generated based on this methodology. After that, core defined facies were used to calibrate MRGC electrofacies. According to core description and electrofacies analysis, the seven lithofacies were defined as: (F1) Pebble sandstone/sandstone with high porosity, (F2) Marly/silty supported conglomerate, (F3) Siltstone/mudstone, (F4) Conglomerate/pebble sandstone, calcite cemented, (F5) Carbonate breccia, matrix and grain supported, with higher content of siliciclastic component, (F6) Carbonate breccia with medium porosity, matrix and grain supported, with higher content of dolomite component, (F7) Tight carbonate breccia, matrix and grain supported, with higher content of calcite component. Results of this classification showed the significant vertical heterogeneity of the reservoir rocks and enabled a more detailed spatial lithofacies distribution.

Theme 15. Sedimentology and hydrocarbons

General Session

Poster presentation

Mud volcanism and seismicity in the Gulf of Cadiz, a symbiotic relationship?

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Mud volcanoes (MVs) are expulsion features ubiquitously present in areas of tectonic convergence. Due to their deep feeding channels, MVs are highly episodic features, acting as valves to dissipate excess pore pressure building up at depth. However, the main drivers behind these sporadic bursts in activity still remain fairly obscure. It is hypothesized that different events could trigger MVs eruptions (e.g. gas accumulation, diagenetic processes, pore pressure build up), but earthquakes (EQs) are the only ones for which a direct cause–effect relationship has been already established. Such episodes of intense activity, which mostly result in powerful mud and/or gas emissions, have been investigated through a multi-methodological approach in the sediments of the largest MV in the Gulf of Cadiz, Ginsburg, and linked to the Holocene EQs occurred in the area. XRF scans of gravity cores and a long sediment core taken with the seafloor drill-rig MeBo display several Barium anomalies, which were interpreted as paleosurfaces derived from seepage events that occurred during periods of intense MV activity. Related seepage during those periods leaves a barite front in the sediments close to the seafloor due to the contact of barium-rich upwelling fluids with downward-diffusing seawater sulphate. Further ED-XRF analyses on sediment samples were performed, confirming the high Ba content of the events detected in the XRF scans, up to 5x higher than background values. Pore water geochemistry data has been used to locate the current SMTZ and to monitor the concentrations of dissolved Barium, Calcium and Sulphur with depth, showing how the episodes of strong seepage in the past relate to the present fluid dynamics. A new high resolution AUV map (1 m) of the Ginsburg MV and several cores on the most prominent mud flows have been used to define the stratigraphic relationships of this complex structure. Radiocarbon dating (^{14}C) of the sampled mud flows, at the interface between the mud breccia (sedimentary facies erupted from the MV) and hemipelagic above, allows reconstruction of the most recent eruptive history, revealing the timing of Ginsburg's episodic activity. Comparison of the mud flows timing with previous paleoseismological data on the area suggests a relationship between large EQs and MVs events.

Theme 15. Sedimentology and hydrocarbons

General Session

Poster presentation

Pleistocene gas-bearing clastic deposits of the Northern Adriatic, Croatia

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In the last few years, driven by high energy prices, shallow gas-bearing deposits have again become a point of interest for researchers. This refers to Pliocene and Pleistocene deposits which appear as the complex sedimentary fill of the Po Depression in the Northern Adriatic Basin. Recent works started in the area west of the Istrian coast in the Ivana gas field, provided comprehensive insight into sedimentary facies and distribution of the Pleistocene Santerno Formation. Its upper part or partly within Carola Formation consists of a frequent alternation of claystones or marls with silt layers of different thicknesses. Unlike claystones, silt layers show no signs of compaction and can be divided into very thin, 0.5–2 mm horizontally laminated layers, 5–50 mm horizontally laminated layers with common remains of vascular plants, thin-shelled bivalves and completely preserved brittle stars, and the thickest silt layers, structureless or with developed planar-cross stratification with ripples on the top, reaching a thickness 100–640 mm. Petrographic composition is relatively uniform; homogenous claystones and marls with less amount of carbonate grains and pyrite, while the medium to coarse-grained silt is composed of quartz, feldspar, micas (muscovite, altered biotite), chlorite and carbonate grains. The Pleistocene (Calabrian) formation age is confirmed by the association of foraminifera (*Neogloboquadrina pachyderma, N. incompta, Turborotalita quinqueloba, Paracassidulina neocarinata, Bulimina marginata*). The depositional environment of the Santerno Formation is defined as the distal part of the Pleistocene Po River prodelta, where the silts and sands are of turbiditic origin. At the same time, the pelitic rocks represent background sedimentation from water suspension. More detailed sedimentological research revealed post-sedimentary mixing and sediment displacement processes to create a final image. The spatial distribution of silt facies with favorable permeability properties and associated pelitic seal rocks should be essential parameters for future activities planning. Data recovered from quality cored samples, together with newer seismic surveys and other advanced exploration methods, can lead to possible new hydrocarbon discoveries in the Ivana gas field and of northern Adriatic.

Theme 15. Sedimentology and hydrocarbons

General Session

Poster presentation

Depositional control over oil reservoir quality in aeolian sandstones: a case study on the Triassic Piramboia Formation, Paraná Basin, SE Brazil

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The Piramboia Formation comprises an oil-reservoir succession originated in a dry aeolian environment that is part of the Paraná Basin petroleum system. This study aims to establish the relationship between the original bedform morphology and the reservoir quality. Two main architectural elements were identified: simple sets (SSs) and compound sets (CSs) of cross-strata. SSs are arranged in tabular-shaped beds of tangential cross-stratifications, delimited by interdune surfaces. Grainflow (20–50 mm thick) and wind-ripple lamination deposits (4–15 mm thick) are interdigitated in the lowermost parts of the cross-stratified sets. These features and the unimodal foreset dip-azimuths (towards SE) suggest that they originated by transversal simple dunes with well-developed slipfaces. The predominance of grainflow strata implies a continuous and rapid rate of dune migration. SSs show a moderate volume of oil saturation (≤ 30%), generally concentrated in grainflow deposits. The CSs of cross-strata are tangential cross-stratifications, in which the individual sets are delimited by low-angle superimposition surfaces. Grainflow strata (18–60 mm thick) is the basic stratification type and display a higher volume of oil sands (≥ 30%). The architectural organisation of these deposits suggests the construction of transversal draas. Bitumen saturation seems to have been controlled by the distribution and thickness of grainflow deposits, whereas wind-ripple lamination mostly exhibits no or low oil saturation. These differences are likely related to the high perm-porosity values of grainflow deposits. Indeed, these deposits tend to form well-sorted and loosely packed sandstones, thus operating as preferential paths of oil migration and accumulation. Transversal dunes with well-developed slipfaces and high migration rates produce a significant volume of grainflow strata, indicating this dune type tends to originate high-quality oil reservoirs.

Theme 15. Sedimentology and hydrocarbons

General Session

Poster presentation

Petrophysical characteristics and oil storage in the Piramboia Formation aeolian sandstone reservoirs, Paraná Basin, Brazil

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Aeolian sandstones are excellent hydrocarbon reservoirs. However, they present important heterogeneities that can imprint relevant flow barriers. This work is an ongoing study that compares the quantitative permo-porosity data of oil-sand aeolian successions of the Piramboia Formation (Permian, SE Brazil) with the data available in literature for analogous aeolian reservoirs. Petrographic analyses, percentage calculation of porosity and oil saturation values were performed in grainflow and wind-ripple deposits using the JMicroVision software. Infrared spectroscopic data from non-imaging instruments (i.e., ASD FieldSpec-4) was incorporated to identify the oil and clay mineral composition. The grainflow deposits consist in quartz (90%), feldspars (8%) and accessory minerals (1%), medium grained sand, well-sorted with straight/long contact, resulting in loose packing of the grains. Wind-ripple lamination are composed of quartz (80%), clay minerals (10%), feldspars (9%) and accessory minerals (1%), medium to fine grained sand, well-sorted with straight/long contact, but more pronounced, resulting in robust packing of the grains. The values of porosity and the oil saturation defined the grainflow deposits as the most suitable oil reservoir, having a porosity of 46% and bitumen saturation of 27%. Wind-ripple lamination deposits have lower porosity (35%) and saturation (16%) values. The samples collected close to the interdune and superimposition surfaces, present a higher proportion of clay minerals (up to 30%), and the lowest rates of porosity (22%) and saturation (11%). Spectral data showed montmorillonite as the main clay mineral. This probably was originated from feldspar alteration during diagenesis. Thus, the values obtained for porosity and oil saturation are compatible with literature records involving non-impregnated aeolian successions. The petrophysical characteristics of grainflow deposits, including grain packing, favoured the concentration of oil in the rock. Wind-ripple lamination deposits and bounding surfaces disposition can produce important flow barriers to oil. This occurs due to the robust packing of the grains and the significant presence of clay minerals that confer a greater degree of heterogeneity to these deposits.

Theme 15. Sedimentology and hydrocarbons

General Session

Poster presentation

Sedimentary characteristics and reservoir differences of shallow water delta in Yangjiang Sag, Pearl River Mouth Basin

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The study area is located in Yangjiang sag, Pearl River Mouth Basin, South China Sea. There are few wells in the study area, and development has only begun in recent years. There are few previous studies. The low permeability layer and conventional layer of the main oil layer in the area are mixed, and the analysis of the main controlling factors of the reservoir is not clear, which makes it difficult to predict the sweet spot of the reservoir. The distribution law of sand bodies in the area is unknown, which cannot accurately provide guidance for subsequent development work. By using core, logging, seismic and other data, sedimentary facies are studied. Based on the electrical and elastic logging data, the BP neural network model is used to predict the microscopic pore structure of each main reservoir. Using Fisher discriminant and dimension reduction method, the lithology is classified and identified, and the porosity and permeability parameter interpretation model is established. The research shows that the source of the study area is basically from the northern delta. The relative sea level gradually rises, the source supply decreases, the delta retreats to the land, and the whole shows the characteristics of transgression, and the marine delta and shallow shelf sedimentary system are developed. The delta is mainly formed in the inner sea with weak wave action and strong tidal action, and some layers develop event storm deposits. Conventional reservoirs and low permeability reservoirs coexist in the area. The low permeability reservoirs are mainly argillaceous low permeability reservoirs and calcareous low permeability reservoirs. The argillaceous low permeability reservoirs are mainly distributed in weak hydrodynamic environments such as estuary dams and sheet sand. The calcareous low permeability reservoirs are mainly distributed in underwater distributary channel, estuary dam and sheet sand microfacies, and vertically distributed at the junction of sandstone and mudstone. On the whole, the sedimentation of braided river delta front controls the reservoir fabric characteristics to affect the development of low permeability reservoirs.

Theme 15. Sedimentology and hydrocarbons

General Session

Poster presentation

Sedimentary characteristics and reservoir property of deep lacustrine fine-grained rocks in Shengbei area, eastern China

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The fine-grained rocks of deep lacustrine subfacies are developed in the lower third member of Shahejie Formation in Shengbei fault downthrown side in the northeastern Dongying Sag, Bohai Bay Basin, eastern China. The fine-grained rocks mixed with calcareous components and coarse terrigenous debris from 0.0039–0.0625 mm near the fault, and mixed with calcareous components and fine terrigenous debris below 0.0039 mm gradually transit to the center of the subsag. For a long time, previous studies on the sedimentary characteristics and reservoir differences of deep lake fine-grained rocks in this area have been controversial. Based on the core observation and lithology variation in this area, six kinds of sedimentary rock microfacies and three kinds of mixed assemblage are divided by the combination of rock mineral composition and organic matter content. Based on thin section identification and test analyses, combined with sand group division, sedimentary assemblage and reservoir property are analyzed. The results show that: (1) The hydrodynamic force is strong near the edge of the basin, and gradually weakened toward the center of the depression. Low-density turbidity current deposits and bio-chemical mixed deposits are developed respectively. (2) Logging interpretation templates are established by using logging data, which can effectively distinguish class A to F: organic-rich calcareous mudstone facies, organic argillaceous limestone facies, organic-rich sandy mudstone facies, argillaceous sandstone facies, calcareous sandstone facies and pure mudstone facies. Under the condition of deep burial, class A and B generally develop irregular bedding micro-fractures, resulting in abnormally high porosity. It is defined that the mixed ABF is the mixed combination I, and the mixed AEF is the mixed combination II, and the mixed ACD is the mixed combination III. The mixed assemblage shows typical banded distribution characteristics. (3) Laterally, the mixed assemblage of deep–middle–edge of the basin is I–II–II in turn, and the reservoir performance is excellent–poor–optimal change. Vertically, the reservoir physical properties have certain regularity. Bounded by class B and class D, the farther away from them, the better the reservoir performance is.

Theme 15. Sedimentology and hydrocarbons

General Session

Poster presentation

Reservoir characteristic and its relationship with Estimated Ultimate Recovery of Jurrasic tight shelly limestone reservoir in the central Sichuan Basin, southwest China

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A combination of reservoir geological factors and a decline-curve approach were applied in a play-wide analysis, to reveal the relationship between the reservoir characteristics and Estimated Ultimate Recovery (EUR) of the reservoir of Da'anzhai Formation. The reservoirs are mainly medium to thick-bedded shoreline–shallow lacustrine tight shelly limestone deposits interlayered with black shales, showing logging characteristics of low gamma ray (below 30 API), low acoustic time (47–55 ms/ft), high resistivity (between 1000–10000 Ω·m) values. High-energy shelly shoals are favourable reservoir facies circular distributed around the lacustrine basin on planar in central Sichuan basin. Fractures, karst caves, microfissures, intergranular and intragranular pores, and matrix pores are recognized in the Da'anzhai Formation, microfissures and secondary pores are dominant reservoir space. What's more, reservoir fractures, karst caves and matrix pores of the reservoirs are all oil-bearing. Physical properties of reservoir are super-low porosity and permeability with an average porosity below 1% and an average permeability between 0.001–0.01 $\times 10^{-3}/\mu m^2$. As a result, all the oil-bearing matrix pores and fractures in the reservoir correspond to the decline curves of exponential decline, logarithmic decline and power-law exponential decline from the production wells, with diminishing EURs of 86.1 MSTB, 39.3 MSTB and 5.9 MSTB (Mille Standard Tank Barrel) (P50) respectively. The proportions of megapores, macropores, mesopores, micropores, and nanopores in the reservoir were 1.6%, 3.7%, 18.1%, 27.8%, and 48.8%, respectively, and the corresponding EUR ranges tended to be above 294 MSTB, 110 MSTB to 294 MSTB, 37 MSTB to 110 MSTB, 4 MSTB to 37 MSTB, and below 4 MSTB. Thicknesses of fracture segments and thickness ratios of dissolved cave segments to the reservoir were positively linearly related to the EUR.

Theme 15. Sedimentology and hydrocarbons

General Session

Poster presentation

Depositional characteristics of microbial carbonate reservoir and their effects on favorable reservoir distributions of the IV Member of Sinian Dengying Formation, Gaoshiti–Moxi area, Sichuan Basin, Southwest China

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Previous scientific research on reservoirs of the Deng IV Member in Gaoshiti–Moxi area concerns on karst paleogeomorphology reconstruction, facies distribution on platform margin and their effects on favorable reservoirs. However, the quality of microbial carbonate reservoirs is also closely related with their original depositional environments on the whole platform. This paper attempts to reveal favorable microbial carbonate reservoir characteristics and sedimentary effects on their distribution and prediction, based dominantly on both sequence stratigraphy and facies analysis, such as seismic facies, microfacies and microfacies associations. The results show that favorable reservoirs of the Deng IV Member are classified into three types according to their space types. Secondary dissolution pores and cavities are primary reservoir spaces developed mainly in non-skeletal grain dolomites with sparry cements, thrombolites, and stromatolites in microfacies association 1 (MA1), MA2, MA5, and MA7. Physical property of fracture-cavity type of reservoir is better in the upper and lower parasequence sets with a porosity between 1% and 5%, a permeability between 0.01×10^{-3} μm^2 and 1×10^{-3} μm^2; physical property of pore-cavity reservoir is fine throughout all the parasequence sets with a porosity between 2% and 4%, a permeability between 0.01×10^{-3} μm^2 and 1×10^{-3} μm^2; physical property of pore-cavity reservoir is the worst. In vertical, the favorable reservoirs are developed mainly in parasequence set 6 (PSS6) and PSS7 in vertical. On planar, they are distributed in well zone MX9–MX19–MX1 for the fracture-cavity type, MX105–MX110–GS20 for the pore-cavity type and MX17–MX107–MX41–MX102–GS102 for the pore type. What's more, to some extent, fracture-cavity type of reservoir is constrained by the top boundaries of PSS7, PSS2, parasequence 17 (PS17) and PS14; pore-cavity type of reservoir by the top boundaries of PSS7, PSS4, PS18 and PS12; pore type of reservoir by the top boundaries of PSS7, PSS6, PSS3, PSS2, PS18, PS17, PS14, and PS12. Seismic facies associated with shoals and mound-flat complex are related with facies distributions of pore cavity and pore reservoirs. MA1, MA3, MA7, MA8 are predominant microfacies associations of favorable reservoirs of the Deng IV Member in Gaoshiti–Moxi area.

Theme 16. Techniques and technologies in sedimentology

General Session

Oral presentation

Using ground-penetrating radar (GPR) to investigate the deposits from the Storegga slide tsunamis in the Shetland Islands, UK

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We present the first results of GPR investigations of tsunami deposits in the Shetland Islands, UK. We include examples from four sites where tsunami deposits are recorded in previous studies from boreholes and outcrops that provide ground-truth. At these locations, Ayr of Dury, Basta Voe, Scatsta and Whale Firth, we investigate the geometry, inland extent, and continuity of sand layers. In addition, we describe survey results from one site, Grimister, where deposits are not exposed and have not previously been reported, to test the potential of GPR to identify candidate tsunami deposits in areas that are not well documented. Tsunami sand layers can be clearly imaged at all five locations because the tsunami sands on the Shetland Islands are interbedded with peat and the contrast in lithology gives a good reflection on GPR profiles. This includes very thin sand layers, less than 1 cm in thickness, that are beneath the theoretical resolution of the GPR. 2-D and 3-D surveys show that tsunami deposits appear to drape a buried topography. Most sand layers form continuous although some gaps are identified and attributed to later erosion, most likely by streams. Sand layers have been traced up to 150 m inland and 10 m above the present shoreline which is consistent with data from boreholes. If a similar sized event occurred today it would have a devastating impact on the Shetland Islands.

Theme 16. Techniques and technologies in sedimentology

General Session

Oral presentation

Exploring the genesis of deep and ultra-deep fractured carbonate reservoirs based on fracture–water–rock simulation experiments and modeling

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Deep and ultra-deep marine carbonates are rich in hydrocarbon resources and are potential areas for China's energy succession. A breakthrough was made in exploring ultra-deep ancient carbonate strata in the Shunbei region of the Tarim Basin in China. The main target layer is the Ordovician Yingshan Formation – Yijianfang Formation, with a burial depth of 7,200–8,000m. The reservoir space is a system of fractures and cavities formed by tectonic activities with strong spatial heterogeneity. Structural fault and fluid activities play a vital role in controlling the formation and distribution of carbonate reservoirs. Based on the geological background above, the objective of this study was to investigate the interactions between fractured carbonate reservoirs and formation fluids under geological conditions. Specifically, we carried out a series of reactions of fractured limestone core samples in brine with dissolved CO_2 from atmospheric to high temperatures and pressures (T=50–200 °C, P=10–60 MPa). Microscopy, SEM and spectral measurements, XCMT scanning, fluid chemistry analysis, and TOUGHREACT numerical simulations were used to qualitatively and quantitatively characterize changes in the fracture area and volume, sample porosity and permeability, calcite dissolution amount, and cation concentration in the fracture. The influence of heterogeneity and fluid flow on the fracture–fluid–rock interaction was explored, and thus the conditions and locations favorable for reservoir formation were clarified. The results indicated that the volume of the main fracture increased after the reaction, the permeability of the sample increased by orders of magnitude, and its porosity increased accordingly. The overall reaction during the experimental period was dominated by the dissolution of calcium carbonate, and no calcium carbonate precipitated. The structural heterogeneity and hydraulic properties make the main flow channel as main reservoir space. Branch fractures or microfractures can weaken the main fluid flow rate and tend to result in the accumulation of solutes, the ends of which may be potential locations for mineral precipitation. Therefore, the priority exploration location for deep and ultra-deep fractured reservoirs should be the main fractures upstream of the fluid flow.

Theme 16. Techniques and technologies in sedimentology

General Session

Oral presentation

Application of a semi-automatic method for sedimentological mapping

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Sedimentological maps, which are useful for understanding sediment dynamics, modelling sediment transport, and supporting sediment management, are important components in analysing coastal environments. Usually, sedimentological maps are based on the collection of superficial samples with different spatial distributions; however, the density of sampling is often low due to the need for optimising time and cost. A low sampling density may not be an issue to map coasts with standard bathymetry and seaward-fining sediment distribution but become critical in the presence of bathymetric anomalies. In fact, both sedimentological and morphological settings are the result of the coastal processes, and in these cases, even advanced automatic interpolation techniques cannot produce maps that properly represent the sedimentological signature of the morphological set-up. The presence of relict landforms, the Isonzo River sediment supply, and the westward littoral drift make the littoral of Grado (North Adriatic Sea, Italy) a good example of such an anomalous coast. Here, the morphological and sedimentological settings, coupled with a sparse and irregular sampling distribution, make an experienced assessment necessary to identify and solve critical issues in the sedimentological maps obtained through automatic algorithms. To construct more reliable maps of the study area, we propose a semi-automatic method based on four steps: (1) identify the incongruities of the automatic models by a match with the landforms; (2) draw polylines between samples to manually force the direction of interpolation; (3) generate simulated samples on the polylines in order to (4) interpolate both collected and simulated samples. In the study area, this approach was able to effectively represent the sedimentary anomalies caused by relict and active morphologies, both interpolating current samples and re-analysing old data with different sampling distribution. Each grain-size parameter distribution can be modelled using this technique, which can also be applied in other fields. The main benefits of this method are its ability to (1) increase useful data density without spending too much time on sediment sampling, (2) re-analyse old data, and (3) tune models only where they are unreliable.

Theme 16. Techniques and technologies in sedimentology

General Session

Oral presentation

Innovational techniques in sedimentology – new insight on Witów Series gravels

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Sedimentological research of Pliocene–Early Pleistocene fluvial gravels and sands of the "Witów Series" (southern Poland, The Carpathian Foredeep) has been conducted for more than 70 years. However, this well-known braided river sedimentary succession was not subjected to investigation using an integrated set of quantitative methods to date. The present preliminary contribution is aimed at: (1) implementing a statistical and multivariate approach, in line with present trends in continental clastic sedimentology; (2) investigating the interrelations between 4 measured variables, detecting patterns in these, and correlating them with paleoenvironmental variables. The study was based on a 4.4 m thick interval exposed in Witów gravel pit. The pebbles were sampled along the log in intervals of 10 cm. From each sampling interval, a minimum of 30 grains heavier than 5 g were measured and identified as either sandstones, quartz, cherts, or granites. The measured variables were: 3 dimensions (a, b, c) of each grain and their mass. The data were subjected to projection in the box plots, Sneed & Folk, and Zingg diagrams, PERMDISP test, and Principal Component Analysis. The dominant grains are bladed, prolate, and oblate shapes according to Sneed and Folk diagram. The PERMDISP test allowed to rejection of the null hypothesis of the absence of variance along the profile. The PCA scatter plot shows the positive correlation between grain dimensions and mass, which in turn are inversely related to stratigraphic depth. The PC 1 axis can be interpreted as reflecting variations in the flow regime, and an overall decrease in river transport competence to the top. The PCA results indicate that further investigations should follow, based on a larger sample size from additional logs.

Theme 16. Techniques and technologies in sedimentology

General Session

Oral presentation

Cold and arid Late Quaternary climate oscillations as recorded in Lanzarote (Canary Island, Spain)

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The Canary archipelago, about 100 km west from the African coast, comprises seven volcanically active major islands compose of basaltic lavas derives from a hotspot over which the Atlantic oceanic crust, is shifting since 60 Ma. Lanzarote is the easternmost of the Canary Islands and dominated by deeply eroded volcanic massifs (i.e. Los Ajaches and Famara) forming abrupt cliffs. The climate, established in the Pliocene as consequence of the closure of the Panama isthmus and the beginning of the North Atlantic current circulation, is very dry (hot and arid), almost desert (126 mm/y rain). The well-exposed Famara cliff, remnant of Miocene shield volcano, is mostly characterized by steep-sided active erosive gullies at the foot of which several alluvial fans develop and merge the wide El Jable plain where they also interfinger with aeolian deposits. These alluvial systems has been luminescence dated (pIRIRSL) using k-feldspar basalt derived grains. Obtained ages range from 96.7±5.58 to 14.02±3 ka; that is, from Marine Isotopic Stage (MIS) 5 to latest MIS2. Our attention has been given to the distal part of the fan system. This is characterized by an alternation of sandy and silty deposits encased on a gravelly channel body luminescence dated at 24.0±2-14.02±3 ka, (MIS2), and possibly related to the Heinrich cold event H1. The rhythmic alternation of sand-sheet flows and silty pond-like strata has been dated ^{14}C dated at 10190±49.5, 6645±5, 3783±89, 3991±94 ka BP; that is to the Middle/Late Holocene (MIS1) and seem to fit well with some Holocene major climate fluctuations. Specifically it fits with aridity peaks such as Bond event 7 – Sahara aridity, Bond 6.7 – aridity pick, Bond 5 – aridity 8.2, Bond 3 – the 4.2 event and the tail of Bond 3. The derived geochronological framework seems to point that the deposition of the distal alluvial fan occurred during the early phase of the Late Glacial Period. ^{14}C ages, instead, strongly support the evidence that major cold-and-dry Bond events left their signature in the depositional record.

Theme 16. Techniques and technologies in sedimentology

General Session

Oral presentation

Multi-sparse inversion spectral decomposition technology and its application in carbonate sedimentary cycle division and facies zone identification

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The Permian Changxing Formation reef and Feixianguan Formation oolitic beach reservoir are developed in the platform margin zone on the west side of the Chengkou–Exi Trough in the Sichuan Basin, but it is difficult to accurately depict the sedimentary interface and to implement the distribution of favorable reef beach facies. For this reason, we propose a multi-sparse inversion spectral decomposition technique, which has higher time–frequency resolution compared with common time-frequency analysis techniques. The core algorithm is a new high-resolution, well-focused sparse inversion spectral decomposition method (SISD) based on lp norm constraint. This technique uses convolution model to construct inversion equation, uses lp norm constraint condition to generate sparse time–frequency distribution, and uses fast iterative soft threshold algorithm (FISTA) to solve lp norm regularization problem. Compared with the traditional l1 norm constrained sparse inversion spectral decomposition, the high-resolution results obtained by the new method can detect more geological details underground, which is conducive to thin layer identification, facies zone characterization and sedimentary cycle division. On the high-resolution instantaneous frequency profile calculated by this method, the frequency of the middle and lower part of the Feixianguan Formation (transgressive system tract) gradually decreases from bottom to top, and after reaching the maximum flooding surface (the middle part of the Feixianguan Formation), enters the regressive system tract, next, the frequency gradually increases, indicating the depositional environment with relatively strong hydrodynamic conditions, which are favorable sedimentary environment of oolitic beach, showing that the high-resolution instantaneous frequency profile is helpful to the fine division of sedimentary cycles and the reservoir prediction. In addition, the frequency division phase spectrum attribute calculated by this method is significantly better than the conventional phase attribute in describing the platform edge zone boundary of Changxing Formation, which improves the recognition ability of platform edge zone and is conducive to the prediction of reef reservoirs.

Theme 16. Techniques and technologies in sedimentology

General Session

Poster presentation

High resolution cyclostratigraphy of the Upper Carboniferous coal-bearing strata: the need for new approaches and concepts

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Recent advances in U-Pb radioisotopic dating of tonstein-hosted zircons by CA-ID TIMS have stimulated a debates regarding the timescales of sedimentary cycles and mechanisms that control the cyclothems formation of the Upper Carboniferous coal-bearing strata (autogenic vs. allogenic controls). As being the highest precision dating method, the CA-ID TIMS has achieved a resolution of few kyr and thus exceeds the resolution of biostratigraphy. Further benefits come from combination of 'chemical abrasion' technique with non-destructive SHRIMP method. As a result, it has become possible to track cyclic patterns in response to quasi-periodic oscillations in orbital parameters (Milankovitch cycles) that result in climatic fluctuations and subsequent biotic changes. Two processes are most likely to produce astronomically-controlled cyclic patterns in sedimentary record: (1) glacioeustatically-driven sea-level fluctuations in case of paralic basins located on coastal lowlands, (2) variations in distribution of the rainfall and the balance of the precipitation and evapotranspiration in terrestrial environments. However, the link between orbitally-driven climatic changes and upstream changes in sediment supply is much less understood and therefore, the new analytical approach is essential to recognize an allogenic origin of the cycles in fluvial systems record. Hence, the on-going research is aimed to respond to the question how precise cyclostratigraphic models might be established for land-locked areas using the Upper Silesian Coal Basin fill (Poland, USCB) as a case study. As the USCB has been recognized in detail through several dozen deep boreholes, providing the big geological dataset and key correlation markers, this area appears to be particularly suited for the studies of the sedimentary record of the orbitally-induced cycles. The classic facies analysis will be supported, for the first time, by geochemical studies of paleosols, high resolution macrofloral biostratigraphy, and high-precision age dating via both CA-ID-TIMS and SHRIMP.

The work is funded by the National Science Centre, Poland under the Weave-UNISONO call in the Weave programme (project no. 2021/03/Y/ST10/00075) and the Czech National Grant Agency (GACR) within the project no. 22-11661K.

Theme 16. Techniques and technologies in sedimentology

General Session

Poster presentation

3D Geological model of the Paleogene deposits in bauxite-bearing district Snižnica (Posušje, BiH): from visualization to finding new bauxite deposits

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One of the economically most valuable bauxite deposits in the Adriatic Carbonate Platform (AdCP) originates from the terrestrial phase between the Upper Cretaceous and Paleogene. The bauxites formed during Upper Cretaceous–Paleogene emersion are present on the entire AdCP. One of the largest and most explored and exploited area is the bauxite-bearing area of Posušje in Bosnia and Herzegovina. Geological exploration and exploitation were continuous and intensive between 1950 and 1990, but after that, all works were stopped by war. In the last ten years, research has started again, and exploitation has been stable with a tendency to increase. This work results from the new research combined with old data collected by Rudnici Boksita d.o.o. Posušje. Footwall to the bauxite deposits are thick Cretaceous rudist limestones, and the hanging-wall is composed of diverse carbonate and clastic sediments of the Paleogene age. This work aimed to collect all available data, systematize them into a 3D geodatabase and construct a 3D geological model of Paleogene strata in Snižnica locality, one of the most complex districts in the area. This work results in a new geological map, 15 geological cross-sections, and a 3D geological model of the Paleogene strata. The 3D model shows the spatial distribution of different Paleogene lithofacies, and the thickness of Paleogene deposits, which is important for drilling planning and reconstruction of eroded parts of the Paleogene deposits. The thickness of Paleogene deposits ranges from 0 to almost 200 m, while the eroded part of Paleogene deposits reaches up to 100 m. The 3D geological model also indicates that the largest amount and largest deposits are located under the clastic series of deposits, especially if the eroded part is taken into account. The constructed 3D geological model and the conducted analysis can serve as a basis for planning further exploration works, primarily drill-holes to find new bauxite deposits.

Theme 16. Techniques and technologies in sedimentology

General Session

Poster presentation

Late Glacial depositional model of fluvio–aeolian succession in central part of European Sand Belt

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Fluvio–aeolian succession is characteristic of the European Sand Belt (ESB) and was created by fluvial and aeolian deposition at the turn of Waichselian and Holoecne. In the central part of the ESB, this succession is documented in both large valleys, regardless of their rank, and small, now dry, denudation valleys. This prompted the authors to present a deposition model. This was accomplished on the basis of studies of sedimentary profiles located on the higher terraces of river valleys, in denudation valleys and on outwash and fluvial plains. Sedimentary succession begins with a fluvial unit, associated with the environment of a braided river. It is composed of sands or sands with gravels with trough cross-stratification, transitioning to silty sands with ripple cross-lamination and sands with tabular cross-stratification or horizontal stratification. The second unit – fluvio–aeolian, separated by a deflation surface, locally with a deflation pavement, was formed following alternating (i) aeolian deposition represented by sands with translatent stratification or silty sands with wave lamination and (ii) fluvial in the form of cut-and-fill structures or levels of sands with ripple cross-lamination or horizontal stratification. The closing succession aeolian unit was formed by deposition within the covers and dunes. It is separated from lower unit by a fossil soil or deflation surface. It is built predominantly by sands with high-angled inclined stratification (dunes) or sands with translatent stratification locally overlain by silty sands with horizontal lamination (covers).

Theme 16. Techniques and technologies in sedimentology

General Session

Poster presentation

Dingo NeutronCT: a novel high-resolution and non-destructive method for diagenetic vetting of fossil coral cores for geochronological and paleoclimate reconstructions

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A novel high resolution, non-destructive method of vetting fossil coral core for geochronological and paleoclimate studies is proposed. Neutron computed tomography (NT) is used to circumvent difficulties associated with usual paleoclimate screening methods. This includes overcoming the difficulty of imaging the effects of marine and meteoric diagenesis, unnecessary sample destruction, limited 2D visualisation and unveiling 3D structure otherwise masked by water content in alternative methods such as hyperspectral scanning. For the first time, thermal neutron tomographic scans provide full, high quality 3D resolution of structure and carbonate material phase contrast in fossil coral that is used to identify sections of pure aragonite to be used in geochronology and paleoclimate interpretations. NT scans are performed on a Holocene *Porites* coral from Papua New Guinea that successfully identifies a contrast between secondary low magnesium calcite and aragonite skeletal material. This strategy is applied to a second and third core dataset from the NW and NE margins of Australia, with more complex diagenetic histories. Observations of NT scans of these three core samples are presented, along with comparisons from previous results reported on the same samples using hyperspectral and X-ray CT imaging, geochemical and petrological analysis. Six methods traditionally used to diagenetically screen fossil coral for geochronological and paleoclimate studies are evaluated for their merits and limitations. Their complementary natures are also highlighted. By identifying areas of well-preserved aragonitic skeletons in coral fossil samples, NT has the potential to yield more precise geochronological and paleoclimate results and higher resolution 3D structure when used in combination with other non-destructive techniques.

Theme 17. Open topics in sedimentology

Special Session 17.1. Open Science: data, software, knowledge, and education

Oral presentation

The usage of open-source software applied to students' academic projects

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Software is becoming a fundamental part in the analyses of geological parameters and in the 3D reconstruction of complex geological architectures. The market offers many different solutions, often dedicated to specific geological problems, such as geophysical analyses, structural reconstruction, etc. Although of significant importance, such kinds of software are extremely expensive in terms of costs and PC performance, often limiting their usage in teaching or for degrees' works. In many cases, in fact, students can access it only through academic laboratories, limiting their learning process and their possibility to completely dedicate themselves to the development of their academic projects. This work derives from different experiences maturated during the COVID lockdown period and subsequent years in exploring the potentialities of open-source software (e.g., QGIS and JMicroVision) in modeling geological situations. It presents different geological case histories where the usage of open-source software was fundamental in data analyses, elaboration, and 3D reconstruction, starting from data collected in the field and/or revising literature on specific problems. All the data collected were managed using QGIS, where geological stops, lithological observations and/or bed attitudes were put together with open digital elevation models, topographic maps, measured and literature logs and analyses on gravel-sized detritus roundness, where possible, in a single, extensive dataset. Spreadsheets were configured to calculate bed azimuth trends or reconstruct positions of logged sequences from a starting point. QGIS Plugins were then used to interpolate roundness calculation results or altitude of specific points recovered during fieldwork and/or from open drill datasets, for example, creating key geological beds as mesh surfaces. This approach allowed to reconstruct key-beds in calciturbidite systems, reconstruct paleo-valley profiles, explore grain-size variation in fluvial and turbidite systems, analyze variation of sediment composition in Quaternary fluvial deposits. Promising results indicate that open-source software are useful alternatives to market software, their usage could improve teaching possibilities, and break down financial barriers in the learning process.

Theme 17. Open topics in sedimentology

Special Session 17.1. Open Science: data, software, knowledge, and education

Poster presentation

Open source software and tools for mapping and reconstructing sedimentary sequences

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With the development of the digital era, Earth Sciences are undergoing a revolution in methods for the collection, mapping, analyses, and modeling of geological data. With this purpose, the usage of open source solutions is becoming fundamental to facilitate the work of many researchers worldwide, reducing financial barriers.

This work presents **GIT4MAP** (***Geospatial Information Technologies for MAPping***), designed and implemented by integrating open-source software and tools (QGIS, QField, QFieldSync plugin, and Syncthing) to build an IT-based infrastructure to optimize geological field data collection, integration, validation, and sharing. GIT4MAP was used to compile the geological map 121 (Brescia), commissioned by the ISPRA – Geological Survey of Italy and Regione Lombardia, and publicly-funded by the CARG Project (Geological Map of Italy at 1:50,000 scale). The area is characterized by the presence of a sedimentary succession composed of carbonate to terrigenous deposits accumulated from the late Triassic to the Paleogene time, structured in a thrust-and-fold chain emerging from the Quaternary alluvial, fluvioglacial, glacial, and eolian deposits. GIT4MAP allows the creation of a GIS-based, interactive project shared among different researchers by collecting, editing and visualizing spatially distributed data from any of their personal devices. This results in a real-time mapping of a large geological dataset collected directly in the field (e.g., lithologies, sedimentary structures, bed attitudes, stratigraphic boundaries, tectonic structures) and complemented by already available data (e.g., geological maps, aerial photographs, UAV LiDAR data, stratigraphic logs). A virtual 3D interface of all the aforementioned data can be obtained throughout the QGIS2threejs Explorer plugin, allowing the reconstruction of sedimentary and tectonic architectures in the study area.

All the dataset will populate the ISPRA – Geological Survey of Italy database, becoming accessible to any user through the Geological Survey of Italy Portal (http://portalesgi.isprambiente.it/en).

Theme 17. Open topics in sedimentology

Special Session 17.1. Open Science: data, software, knowledge, and education

Poster presentation

DDE-Outcrop3D: exploring new forms of field geology education and research

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The investigation and observation of geological outcrops is a key aspect of geology majors in teaching and research. With the rapidly developing of UAV technology, live-view 3D technology and computer technology, 3D visualization of geological outcrops in the field has become a very important research tool. When investigating geological outcrops in the field, it is usually limited by natural factors such as time, weather, season, and vegetation cover, and the traditional methods are difficult to comply with the development trend of data-based research. In order to break through these limitations, we have digitally collected more than 90 classic sedimentary rock outcrops in China, including the work of UAV macro-tilt photography, UAV high-precision tilt photography, Insta360 panoramic camera photography, and DSLR camera photography. And the collected data were modeled in 3D to get the model, and the model was uploaded to web platform named DDE-Outcrop3D which designed and developed by our team based on the Cesium open-source 3D earth engine. The platform achieves the visualization of high-precision 3D models of geological outcrops, combining outcrop-related information such as text, pictures, videos, panoramas, documents, observatories, geological maps, etc. with 3D outcrop models, and realizing the uploading and panoramic roaming of outcrop 3D models as well as the self-supply, sharing and visualization of outcrop-related information. The platform was also successfully applied to the 21st International Sedimentological Congress virtual field trip, which received the support and attention of many scientists worldwide. Compared with traditional geological research methods, 3D visualization of geological outcrops helps geologists understand the basic features of geological phenomena and outcrops more comprehensively and intuitively. The platform realizes the construction and sharing of geological outcrop resources in a digital environment, allowing scientists, scholars and earth science enthusiasts around the world to enjoy world-famous geological outcrops and geological relics without having to leave home, which will be applied to scientific research, science popularization and teaching of geology in the future, making fieldwork anytime and anywhere a reality.

Theme 17. Open topics in sedimentology

Special Session 17.1. Open Science: data, software, knowledge, and education

Poster presentation

Sedimentologika: a community-driven diamond open access journal in sedimentology

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Theme 17. Open topics in sedimentology

Special Session 17.3. Sedimentology and geotourism

Oral presentation

Sedimentology behind fascinating scenery and landforms of Mangistau (western Kazakhstan) – implications for geotourism and education

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The Mangistau region of Western Kazakhstan is becoming an increasingly popular tourist destination because of scenic landscapes and spectacular landforms formed by sedimentary processes. The entire Mangistau region is composed of sedimentary rocks (Permian to present), which are usually well exposed because of sparse vegetation. The main natural attractions are: i) the Boszyra landscape: spectacular cliffs and buttes; ii) Sherkala Mountain: a colorful, yurt-shaped hill; and iii) Torysh concretions: up to 3 m in diameter. While dozens of legends suggest the origin of these features, very little is known nor communicated to tourists about the science behind them. The rocks in Boszyra are composed of Cretaceous marine sediments, including deepwater shales and clastics overlain by chalks composed of microscopic coccolithophores that lived in warm and clean seawater. Cenozoic carbonates and shales formed in coastline settings form the thin top layer. Recent erosion has created an awe-inspiring escarpment and isolated buttes. Sherkala Mountain is composed of the same rock succession as Boszyra but is an isolated butte remaining after erosional removal of the adjacent rocks. Concretions occur along a >100 km-long exposure of Cretaceous glauconite sand deposited in dysoxic conditions at depths of tens of meters on a continental shelf. They formed shortly after the deposition by reaction of metal ions, CO_2 and bicarbonates that diffused from organic matter on the inside to the outside of the concretion, before being precipitated as calcite or siderite. Recent erosion of unconsolidated sand has allowed for concentration of erosion-resistant concretions. Other geosites include: i) Aktau's microbial mounds and cliffs composed of bioclasts; ii) Karagie depression (134 m below MSL); iii) dozens of salt pans and playas; iv) preserved KPg and PETM records; v) numerous canyons; vi) free-flowing geothermal fountains; vii) an abandon uranium open pit mine; viii) natural oil seeps; ix) art like colorations of rocks caused by diagenesis; x) coastal dunes; xi) fossils (molluscs); xii) lagoons seasonally inhabited by thousands of flamingos; xii) ancient deltaic and black shale forming systems. Mangistau's sedimentary succession is underutilized for geotourism, education, and research.

Theme 17. Open topics in sedimentology

Special Session 17.3. Sedimentology and geotourism

Oral presentation

As the sea rages

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The island of Mana (NP Kornati, Adriatic Sea, Croatia) is characterized by a beautiful limestone landscape that owes its existence to the geological structure, and to an exposed position to the open sea. In contrast to the scenery that attracts tourists during the fair-weather season, during winter storms the island is not hospitable at all, especially on the wave-exposed rocky shores. A spectacular large accumulation of storm boulders – a few meters thick storm deposit composed of detached bedrock limestone fragments, is recently found in the central lowland of the island (Korbar et al., 2022). An intriguing movie story about a lost tribe – people from the sea, was filmed on the island in 1959. The title of the movie – "As the Sea Rages", unintentionally referred also to a spectacular natural phenomenon – the storm deposit, discovered 60 years after the filming. Besides, in one of the frames of the film, a 6-ton storm boulder was accidentally filmed, right next to the sea. Half a century later, the boulder was found 30 m away from the place where it was filmed, and 3 meters above sea level, at the edge of the storm deposit that is facing the open sea. The results of the latest research on a few solitary boulders that are situated closer to the sea, out of the storm deposit, indicate the last movements of the boulders in 2018, during a well-known major regional storm – probably the most severe storm in the Adriatic in the last decade. So, as the sea rages, the rock breaks, slides, and rolls – up the slope. If global warming continues, the solitary boulders will be in future incorporated into the storm deposit, while the new boulders will be detached from the limestone bedrock. This deposit is the largest reported coastal storm deposit composed of large storm boulders in the Adriatic, and probably the largest of its kind among the semi-enclosed inland seas of the world. This is why this sedimentological phenomenon deserves the highest level of protection, but it should also be used to promote geotourism.

Reference

Korbar T., Navratil D., Denamiel C., Kordić B., Biolchi S., Vilibić I., Furlani S. (2022): Coarse-clast storm deposit and solitary boulders on the island of Mana (NP Kornati, central Adriatic, Croatia). Geosciences, 12/10, 355. https://doi.org/10.3390/geosciences12100355

Theme 17. Open topics in sedimentology

Special Session 17.3. Sedimentology and geotourism

Oral presentation

The Gargano Promontory (Italy): a perfect destination for carbonate sedimentology and geotourism in an aspiring UNESCO Global Geopark

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The Gargano Promontory is an ideal candidate for inclusion in the UNESCO Global Geoparks due to its unique geological features, high biodiversity, and rich cultural and historical heritage. The area has a defined geographic boundary and covers approximately 2000 km^2, making it suitable for local economic development. Impressive geodiversity includes geosites of international interest, and a poorly deformed natural transect from shallow-water to basinal carbonate rocks, as well as karst morphologies, valleys, small canyons, and lagoons. Sedimentological highlights include Mesozoic inner-platform peritidal cycles with dinosaur footprints and accumulations of rudists and *Chondrodonta*, marginal facies with stromatoporoids or ooids, well-exposed slope and base-of-slope facies with a high variety of gravity-flow deposits, and basinal white limestones with colored cherts and frequent slumping. Scattered Cenozoic shallow-water carbonates also offer high geodiversity. The Gargano is already a National Park and preserves high biodiversity, including endemism and ecological singularity, and a UNESCO World Heritage site for ancient beech forests. Archaeological sites of international significance, including Palaeolithic remains and some of the oldest chert mines in Europe, are also present. The Gargano has a rich cultural heritage, including the legend of Archangel Michael's apparition, triggering its history and cultural mixing. The Gargano is a well-known tourist destination for religious and beach tourism and offers great potential as a laboratory for implementing geotourism practices alongside sustainable tourism efforts that prioritize natural beauty, local traditions and cuisine.

Theme 17. Open topics in sedimentology

Special Session 17.4. Sedimentology and archaeology

Oral presentation

Carbonate rocks from the Kraków–Częstochowa Upland (Poland) – host of siliceous rocks – the provenance of siliceous rocks used as raw-materials

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The Upper Jurassic carbonate rocks from the Kraków–Częstochowa Upland (KCU; Poland) are host of siliceous rocks. The three silicification types and products were distinguished: early-diagenetic chert concretions, early-diagenetic bedded chert and epigenetic siliceous rocks. Siliceous rocks originate from silicification of primary carbonate sediments, thus, their formation is closely related to the development of these sediments. Silicification processes were controlled by the properties of carbonates: facies and microfacies, mineralogy, porosity and chemical composition. The siliceous rocks have been used by ancient communities since the Middle Palaeolithic as raw materials for manufacturing of tools. Criteria applied to typological classifications of siliceous artifacts are subjective, ambiguous and unrelated to the geological context of the findings. The terminologies used in descriptions of siliceous rocks are specific for geological sciences and archaeological sciences and correspond to only a limited extent to each other. The siliceous rocks originated from various geological formations and various outcrops can be simply identical macroscopically. All attempts to link siliceous rocks from archaeological sites with particular outcrops or particular regions based on analysis of color, shape, size, etc. are, unfortunately, groundless from the geological point of view. The principal feature, which must be taken into consideration when the siliceous rocks from Upper Jurassic formations from KCU are characterized, is the presumption that their origin is related to silicification of primary carbonate rocks. The basis for macroscopic characterization of siliceous must be the microfacies analysis of their carbonate hosts and find out an approximate position of given microfacies type in the lithostratigraphic column of Upper Jurassic strata.

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Theme 17. Open topics in sedimentology

Special Session 17.4. Sedimentology and archaeology

Oral presentation

How do sea level, climate, and structural controls impact Mid-Holocene paleogeography and Late Neolithic population along the Arabian Sea shoreline (Bar Al Hikman peninsula, Oman)

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Arabia has experienced over the last 12 000 years dramatic climatic and environmental changes that have strongly impacted coastal stratigraphy and human populations. The Omani peninsula of Bar Al Hikman is a modern storm-dominated carbonate ramp-like system (slope ~ 0.01°, 25x35 km) along the shoreline of the Arabian Sea. At the SE edge of the area, along an outcropping regional NNE-oriented fault high, a Late Neolithic site has been reported suggesting human presence in the area starting at 6450 BP and vanishing after 4650 BP. By coupling satellite image analysis, field-mapping, and dating of sediment samples, this study aims to elucidate the relationship between the structural framework underlying the distribution of Holocene sediment, the physical factors leading to the formation of modern geomorphologies and human evolution. A Mid-Holocene to present Relative Sea Level curve and paleogeographic models has been constructed from a digital elevation model and calibrated ^{14}C ages of skeletal carbonate components. Our results show that the Mid-Holocene transgression above present sea-level submerged the peninsula around 7000–6500 BP, peaking with a highstand of 3–4 m above the current sea level around 5200–3900 BP, before falling to the current level. The transgression caused the flooding of a vast part of the peninsula and consequently the development of large intertidal to shallow/subtidal areas (550 km^2) for at least 3000 years. The onset of the Neolithic occupation (6450 BP) corresponds to the beginning of the flooding of the peninsula (currently +1 m above sea level) while its duration (6450 and 4650 BP) fit the Mid-Holocene Highstand (+3–4 m above present sea level). The period of site occupation largely overlaps a climatic change from humid to arid (6100 BP) indicating that the population may have at least temporarily adapted their lifestyle to the changing nature of intertidal environments (i.e., mangroves and intertidal gastropod/bivalve carbonate factory replaced by coral reef/barrier spit systems) until the area finally fell dry. Hence, a key factor for human settlement and its disappearance in Bar Al Hikman during the Late Neolithic/Mid-Holocene was not only the climate but also the presence of a large intertidal/shallow subtidal environment providing food.

Theme 17. Open topics in sedimentology

Special Session 17.4. Sedimentology and archaeology

Poster presentation

Landscape impact and renaturalisation of a Bronze Age human community (Paduli, Colli sul Velino, Central Italy)

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In protohistoric age, the Piana Reatina (central Italy) was occupied by shallow water lakes. Between 1,800 and 900 BC, numerous human communities, dedicated to farming and pastoral activities and organised in small farms or villages, developed around this area. Around the 10th–9th century BC, these communities disappeared and were not replaced locally by urban agglomerations as happened in other sites of the central Italy. Previous researches have hypothesised that the lake level variations were responsible of the depopulation of the area. Sedimentological and pedological studies were realised in the archaeological site of Paduli (Colli sul Velino, Rieti) to verify whether natural phenomena were actually the causes of the anthropic abandonment. Four drill holes to the depth of 5 m, 6 trenches, up to 3 m deep and 7 m long, macroscopic, microscopic, mineralogical and geochemical analyses on sediments and soils were carried out. These analyses have reconstructed that the archaeological site consists in anthropic deposits filling a concave-up depression more than 3 m deep, and c. 20,000 m^2, extended in NNW direction with gentle margins. The anthropic deposits abruptly overlies lacustrine carbonates, locally interlayered with clayey strata and wetland palaeosols (Histosols), and consists in heterogeneous deposits of carbonate, clays, ashes and charcoal. Limestone clasts, pottery fragments, wooded planks, bronze and stone artefacts are scattered throughout this deposit. Overall, the arrangement of these deposits is apparently chaotic, but in some cases charcoal clasts organised in cross-beddings are observe. A poorly developed soil (Entisols) covers the stratigraphic succession. No sedimentological or pedological elements point out an alleged rise in lake or groundwater level. Differently, the geometry and filling of the anthropic deposits indicate that the archaeological site consists in a dug depression filled by waste material. Mineralogical data reveal that the lacustrine carbonate was extracted and replaced with waste. Our hypotheses are that the carbonate material was explored for building purposes and the pit filled by waste material for continuing the use of the area for agricultural or pastoral purposes. This is probably an ancient case of renaturalisation of an anthropised area.

Theme 17. Open topics in sedimentology

Special Session 17.4. Sedimentology and archaeology

Poster presentation

An exploratory paleoenvironmental study on a coastal Palaeolithic site in Albania through an integrated stratigraphic approach (Dalani i Vogël, Vlora)

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The Albanian Palaeolithic is probably one of the least explored periods in the archaeological record of the country. This is partly because research on early prehistoric studies is fragmentary, in contrast to a greater focus on later periods. The joint collaboration between the CNR-IGAG (Milano and Rome), the Institute of Archaeology, Academy of Albanological Studies (Tirana) and the Department of Humanities, University of Ferrara aims to contribute filling this gap by exploring the paleoenvironment of new/poorly investigated Palaeolithic sites in Albania. The Dalani i vogël site was selected for this purpose from a cluster of coastal sites north of Vlora (Triporti–Portonovo area). An outcrop high about 7.5 m and tens of meters wide was sampled for geochronological analyses (OSL and ^{14}C), magnetic susceptibility, sedimentary proxies (Loss-On-Ignition, calcimetry, main nutrients), micromorphology, micropaleontology and microbotanical analyses. The occurrence of Middle Palaeolithic flint artefacts was documented within oxidized sandy silt deposits overlying the basal clayey layer developed from the weathering of the flysch bedrock. These lithic finds, initially collected by amateurs and later identified, consist mainly of Levallois cores, flakes and scrapers. Superimposed on this unit is a silty-clayey brownish layer ca. 1 m thick, archaeologically sterile, with deep cracks, interpreted as a vertic diagnostic horizon. The top of the unit is truncated by an erosional surface characterised by concentration of mycorrhizal fungus Glomus and trilete spores. The overlying unit contains Neolithic pottery. The sequence is sealed by cross stratified silts and sands typical of sand dunes. Pollen is sparse and poorly preserved; concentrations and preservations are both possibly biased by hydromorphic processes, revealed by the strong concentration of Fe-Mn Ox nodules. However, the identification of almost exclusively upland herbs (Gramineae, Caryophyllaceae, Cichorioideae together with other Asteraceae) suggests dominant open and patchy environments. The quartz OSL ages range from 42.9±1.5 ka to 0.09±0.01 ka. Considering the geographical position of Albania, finds pertaining to this chronological interval are expected to shed new light on the Middle–Upper Palaeolithic transition in S-Europe.

Theme 17. Open topics in sedimentology

Special Session 17.4. Sedimentology and archaeology

Poster presentation

Modelling earthquake and palaeotsunami damage scenarios on the coasts of the Eastern Mediterranean between 300–551 CE

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The coastline areas all over the world are inundated by waves of storms, tropical cyclones and tsunamis. During the geological history of the Earth, all of these events are normal and repeatable, occasionally there are of catastrophic scale. However, within the development of civilization, such extreme events have become not only a geological problem but also a human one. Therefore, nowadays the studies of storm, cyclones and tsunami impact are of priority importance. Numerical modelling of fault zones, earthquakes and tsunami wave propagation in recent years has become a widely used method of geological research. Our study proposes combining the results of detailed digital modelling of the range of historical tsunamis that affected the eastern part of the Mediterranean Sea with the primary field observations and archaeological documentation from the ancient Phoenician port of Porphyreon (Jiyeh) on the Lebanese coast. The main goal is to identify the fault that could have generated a strong enough earthquake to lead to the flooding and destruction of Porphyreon as a result of tsunami inundation. Another objective is to indicate with which historical event described in the literature the destruction observed in the Porphyreon archaeological site can be correlated. A side effect is the identification of potential faults that could generate tsunami waves threatening the coast of Lebanon and the southern part of the coast of Cyprus. By combining many disciplines, the developed scenarios made it possible to identify seismic activity in the Mount Lebanon Thrust zone as the most likely cause of the tsunami inundation of the Porphyreon site and a large part of the coast of Lebanon. This scenario coincides with the historical descriptions of the earthquake of 551. The results of the other scenarios can serve as a reference point for researchers analyzing similar phenomena between 300 and 551, and as guidelines for institutions dealing with georisk analysis in this region of the Mediterranean.

Theme 17. Open topics in sedimentology

General Session

Poster presentation

Miocene marine phosphogenesis along the Peruvian coast: origin and sedimentological significance of the Pisco Formation phosphorites

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Phosphorites are sedimentary rocks that have a great economic relevance due to their high content in phosphorus, a central ingredient in fertilizers. Along the Peruvian coast, the East Pisco Basin is known to host phosphorite beds of Miocene age, usually concentrated at stratigraphic unconformities. However, the processes leading to their formation are still poorly understood. Therefore, the objective of this study is to investigate the petrographic and chemical composition of these Miocene phosphorite layers, identifying their mineralogical composition, comprehending the phosphogenetic mechanism(s) and sedimentary dynamics that led to the genesis of P-rich sediments and phosphorite accumulations, and reconstructing the paleoenvironmental conditions that favored their development. Field investigations and sampling were followed by geochemical and textural investigations, carried out by means of optical microscopy, XRD and XRF analyses, SEM, EPMA, ICP-MS, and LA-ICP-MS analyses. Our results indicate that the phosphorite layers are mainly composed of phosphatic clasts showing detrital minerals or fossil fragments at the core and phosphatic coating made of fluorapatite, with minor amounts of terrigenous clasts cemented by dolomite, calcite, Fe-oxides, diagenetic gypsum/anhydrite and baryte. The mineralogical and textural relationships suggest that the phosphorite layers were deposited in a shallow marine environment characterized by high biological productivity and low sedimentation rates. The studied phosphorite beds formed near the sediment–water surface during early transgression phases, at a time when the porewaters were enriched in phosphate due to the presence of organic-rich sediments, as typical of upwelling settings. The concentration of phosphate-coated clasts was favored by sedimentary condensation mechanisms. Overall, this study provides new insights into the genesis of phosphorite layers in the East Pisco Basin and highlights the importance of understanding the complex interplay between authigenic and sedimentological processes in the formation of these economically and geologically significant sedimentary rocks.

Theme 17. Open topics in sedimentology

General Session

Poster presentation

Earthquake-induced liquefaction of Quaternary continental deposits (2020 Petrinja earthquake, Croatia): a sedimentological perspective

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The interdisciplinary research aims to improve the sedimentological and geotechnical comprehension of granular deposits affected by coseismic instability during the Petrinja earthquake. The main shock happened on December 29, 2020, at a shallow depth, with an Mw 6.4 magnitude, within a structural frame associated with transtension deformation. The studied coseismic liquefaction sites are located within a radius of 22 kilometres around the main shock epicentre. Most liquefaction occurred north and northeast of the epicentre, near Petrinja and Sisak, within the Sava and Kupa alluvial plains. Just after the earthquake, an international team (EUTEAM) surveyed the coseismic effects on the natural environment, including about 200 liquefaction points. Most of the surface ejecta were extruded from Holocene point-bar sands and gravels and sedimented into the meander systems of the river Sava and its tributaries Kupa and Glina. The largest ejection and lateral spreading phenomena took place along the active riversides. Our new sedimentological and petrographic research sheds further light on the liquefied granular sediments, recording different depositional environments. Each river shows a peculiar petrographic composition and grain size distribution. Liquefaction involved a wide range of facies, compositions, fabric, and grain sizes, ranging from silt to very coarse gravel. Particularly noteworthy is the coarse to very coarse grain size of ejected materials from Holocene units, including clasts from a few up to 10 centimetres in dimension. Clasts of ejected sediments are mainly constituted of metamorphites, quartzites and chert lithics. The heavy minerals content of the analysed samples (amphiboles, garnet and epidote) also points to a metamorphic rock provenance of the material. Liquefaction also involved other types of sediments, such as older Quaternary (Pleistocene) fluvial deposits, subject to pedogenesis and eroded into forming terraced morphologies. The most peculiar lithologies ejected by liquefaction were gravels showing a sharply angular fabric and prevalent carbonate composition derived from fault cataclasites and slope deposits.

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